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THE SCIENCE OF COMPARATIVE JURISPRUDENCE.

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AN unbeliever in the possibilities of an exact historical science, Mr. Goldwin Smith, has said that history is like a child's box of letters, out of which we may spell whatsoever we please. As illustrative of his meaning, he might have taken the works of any of the old jurists, say Domat or Blackstone, for instance, and shown that that which they called history was too apt to be nothing more than a succession of ingenious but not always happy guesses. Writing upon the history of law, they used only such facts as squared with their preconceived philosophy of law—which philosophy, in its turn, was only another and slightly modified form of their dogmatic theology, from which it was a series of deductions. We owe the old legists, from the time of Gaius to that of Blackstone, a vast debt which we can never pay; but it is for the body of substantive law they have left us, not for their *bizarre* and unscientific speculations as to the origin and philosophy of law.

In his chapter on Rousseau's "Theory of the Social Compact," Mr. John Morley says: "Signal novelties in thought are as limited as signal inventions in architectural construction. It is only one of the great changes in method that can remove the limits of the old combinations, by bringing new material and fundamentally altering the point of view." The truth of this remark is nowhere better shown than in the very matter of which we have been speaking. If we may claim to know more than our forefathers about the actual historical development of law, it is only because we have become possessed of a new historical method which has already wrought signal, if not fundamental, alterations in our point of view so far as regards the origin

and early history of institutions. I of course refer to the comparative method, which Professor Freeman, one of its greatest expositors, says marks "a stage in the progress of the human mind at least as great as the revival of Greek and Latin learning." This method had already led to wonderful achievements in the fields of language and religion, when Sir Henry Sumner Maine made the first noteworthy application of it to legal history in his now famous "Ancient Law." The earliest comparative study of European and Indian institutions was in the department of philology, and served to prove to demonstration that Sanskrit, Greek, Latin, and the Teutonic languages belonged to one common stock, and that the forefathers of Vergil and Sophocles, of the authors of the "Vedas" and the "Nibelungenlied" were related by community of race. This demonstration was soon followed by a great mass of confirmatory proofs from the fields of mythology and religion, and all of this earlier work was absolutely requisite before anything like a successful essay could be made in the field of comparative jurisprudence—so true is it, in the words of Mr. Symonds, that "language and mythology form the vestibules and outer courts to Homer, Phidias, and Lycurgus." The final preparation for a complete and thorough study of comparative jurisprudence was made possible when scholars like Mr. Tylor, Mr. Spencer, and Sir John Lubbock, went a step beyond the facts furnished by Indo-European peoples, and showed that prehistoric man was, to use the words of Mr. Bagehot, "substantially a savage, like present savages, in morals, intellectual attainments, and in religion," and that the prehistoric Aryan was no exception to this rule.

And now, before we define the scope and purpose of comparative jurisprudence—and there has been some doubt as to the propriety of using this term in the sense in which I shall use it—let us determine exactly what is meant by the comparative method. For illustrations and definitions, I might refer to Müller, Pictet, Freeman, and others who have done so much for comparative science, but I turn by preference to Professor Flint, because he has, in a single short paragraph, most happily described the new method, particularly as applied to legal history. "Social phenomena," says he, "such as laws, can not be explained by merely physical phenomena of natural philosophy and chemistry. The most distinct characteristics which they possess lie in their capacities for continuous evolution and development; and it is only by the study of their evolution, by the comparison of their consecutive states, and of each state with the coexisting general condition of society, that we can rationally hope to reach an adequate knowledge of their laws." This method, then, requires not only the study of English, ancient and modern Roman, Greek, and Hindoo law, but the study of the history of each; and not this alone, but the comparison of each with all of the others in such manner as accurately to learn their relations to each other, and to be able to mark off with something of pre-

cision those laws and political institutions which originally they all possessed in common, and which might fairly be denominated Aryan law. This method implies the study of law upon both its statical and its progressive sides, and discloses the processes by which it has been developed. The disclosure of the motives and processes of legal development I regard as unquestionably the most valuable of the fruits of comparative jurisprudence, for just behind them lies that subtile *lex legum* which has eluded the grasp of so many imaginative system-builders, but which is eventually destined to be as familiar learning to the scientific jurist as Grimm's law is to the modern philologer.

It will be readily seen, from this description of the comparative method, as particularly applied to the study of legal history and philosophy, that by the term comparative jurisprudence I mean something more than is usually meant by it when used by lawyers and legislators. These latter use the term as meaning a comparison of the legal systems of distinct and highly developed societies, to the end of the facilitation of legislation and the practical improvement of the law—which I should call comparative legislation. It must be admitted that what is here spoken of as comparative jurisprudence covers an area much wider than the field of law, but it does not therefore follow, as Sir Henry Maine is inclined to believe, that it should be called by some other name. Its field is unquestionably much larger than the field of positive law—which law is, in the words of Mr. Amos, "the enforceable general commands of a state," in the words of Mr. Austin, "law set by political superiors to political inferiors"; but it is not larger than the field of law as it was in archaic society. We may admit the claim that the existence of an organized political power, a state, is a condition precedent to the existence of law as understood in a political society like our own, yet there was law before there was political society, and, although it lacked many elements of the modern idea of law, it nevertheless was the original point of departure, and to it we must look for the historical roots of the positive law of to-day. If comparative jurisprudence deals with religions, ceremonials, customs, and politics, it is because it reaches back to a time when these and law were but slightly differentiated, when law had no peculiar accent of its own apart from that of the other institutional manifestations of social life. It can no longer be doubted that the law of evolution holds good, not only of organic processes, but of all super-organic processes as well—of the development of language, art, law, religion, and political institutions, and that in the beginning they were homogeneous and incoherent. So jurisprudence is compelled to regard something more than law simply, if it is to comprehend law. It has for its subject-matter the study of the relation of the fact law to all of the other facts of society, and so it goes back of positive law and seeks its springs and motives in systems like the early Roman and the Hindoo, where rites, liturgies, prayers, moral ordinances, and what we know distinc-

tively as civil laws, appear to be mingled in mere senseless confusion. If the sphere of comparative jurisprudence is thus rendered larger than that of any of the other comparative sciences, it is only because law is the one social fact in which all others eventually lose themselves, and those others have to be known before law can be known. So jurisprudence requires a knowledge not only, as Ahrens reminds us, of "the group of conditions necessary for the physical and spiritual development of man so far as these conditions are dependent on human will," but of physical and spiritual conditions which predetermine law, and to which man has been no voluntary party.

In seeking the causes of ultimate social phenomena, we must always look to the history of the human mind, and its conditions antecedent to those phenomena. The most archaic—and I mean archaic in point of structure rather than in point of time—as well as the most modern social facts grow out of contemporaneous habits of thought. If the institutions of the earlier time or of the less civilized people differ materially from those of our civilized states, it is mainly because of difference in conditions and methods of thought. The introduction of the history of manners and institutions into general history accomplished a great revolution in methods of historical inquiry, for it laid open the hidden springs of national strength or weakness. It was Montesquieu's good fortune to be the first to successfully demonstrate this, but later on Jouffroy saw farther back along the line of cause and effect and clearly pointed out, what Mr. Herbert Spencer has since demonstrated, namely, that the chief agent in social evolution is belief.

It is not enough, then, for the student of comparative jurisprudence to know that archaic society presents startlingly vivid contrasts to the society of our day; to know that that political society which generations of inquirers have regarded as primordial is of recent growth; that time was when there was no state, no contractual, testamentary, or proprietary right in the individual—when the whole law, as yet customary, was summed up in status and kinship. If we are to account for these things, we must account for the state of society in which they existed; and, although such inquiry is not strictly or in any sense exclusively juridical, it is nevertheless prerequisite to a thorough and trustworthy comparative jurisprudence.

In proof of the last proposition, let us trace some of the steps that have been taken in the endeavor to find the ultimate reason of ancient law. Maine first followed back laws as far as the patriarchal family, which he justly calls "the type of archaic society in all the modifications which it is capable of assuming." But he makes no endeavor to account for the family, except by reference to the power of the father. He sets it down as a primordial and inexplicable social fact. He admits that he can not regard a disinclination to accept it as such as altogether unnatural, and yet he avows that he finds nothing in the superficial passions, habits, or tendencies of thought which at all sufficiently ac-

counts for it. He recognized the value of a knowledge of the organizing cause of the family in antiquity, but gave up the search for it as hopeless. Others, more hopeful, have succeeded where he failed, until it has now been reduced to certainty that the constituent bond of the family was neither the *patria potestas*, nor simple community of blood, nor natural love and affection, and that neither of these things suffices to explain its existence, but that it finds its ultimate reason in religious principle and practice. In his treatise on "Hindu Law," Mr. John D. Mayne shows that ancestor-worship is the actual governing motive of native Indian jurisprudence to this day—ancestor-worship, the same principle which Coulanges so skillfully proved to be anterior to all Aryan social institutions, and which Spencer has found to be universal among all primitive peoples and the radical principle of all known religions. Coulanges erred in making the worship of the dead a finality, just as Maine erred—an error which I believe he has partially recognized—in believing the resources of his science insufficient to penetrate behind the *patria potestas*. The reason of ancestor-worship is discovered in the physical condition of primitive man, in his earliest methods of thought, his ideas of life and death, of life hereafter, and of the divine principle. Just as the student of the history of Roman law is forced to never lose sight of the patriarchal family—the nidus of those rudimentary ideas which are to the jurist what the primary crusts of the earth are to the geologist—so the student of the Aryan household must not only ever remember that its source is in the sentiment of religion, and that "the one unfailing centripetal force of archaic society" was community of worship, but he must go further, and place himself in a position to fully realize ancient habits of thought at the time when ancestor-worship was the dominant form of belief. To try to account for that belief by reasoning after our own approved methods—methods which at first seem to us to be the natural and only possible ones—is to grope hopelessly in the dark. We must make an effort to reconstruct primitive man on his intellectual side, as the paleontologist does on his anatomical side, and then to think as he thought. Here we leave our special department of laws and customs, and take up the study of general culture history; and, if in going back we lose distinctness and coherency, we shall find nevertheless the thing which shaped the thought at its birth, and that is the essential matter.

The only scholar who has as yet made any systematic and noteworthy effort to discover the causes of the primitive universality of ancestor-worship is Mr. Spencer, and his views are most worthy of attention, however liable they may be to future modification. He contends that ancestor-worship may be explained by having recourse to the ideas concerning sleep and dreams entertained by the earliest men, while they are still incapable of generalization and without any correct idea of causation and law, "lacking the very implements of

developed thought." These ideas, he claims, account for primitive doctrines of immortality, which latter beget the worship of ancestors. Whether or not this theory of Spencer's, or Coulange's theory that early ideas of generation and creation afford the clew to the mystery, satisfactorily accounts for this primitive practice, the fact nevertheless remains, that the deification of the dead is the oldest religion known to men, which religion is the efficient cause of ancient social organization, the essential principle of archaic institutions, archaic morals, and archaic laws.

As to what those institutions and laws were, a simple discussion of the scope of comparative jurisprudence does not afford opportunity for inquiry. That they were utterly different from those of our own day may, however, be said. It seems to us, regarding law by the light of reason alone, that it must be somewhat more than immemorial usage, that it should acknowledge the principle of amendment and growth, and that it is something separate and distinct from religion; and yet ancient societies had an entirely different notion of it, regarding it as the revelation of some deity, hallowed by custom, and absolutely immutable in its principles, being nothing less than "religion applied to the relations of men among themselves." And so it would seem, from the reason of the thing, that there must always have been a law of contract as known to us, yet society had become far advanced in civilization before any such law was recognized and formulated. It would seem that the individual must always have held property in his own right, must always have been at liberty to dispose of it by some method of alienation during his life, and prescribed by will or testament some disposition of it after his death; and yet individual property and rights of alienation and testamentary bequest are, so to speak, new-fangled notions. In the same way we have come to regard local contiguity as the only possible basis of common political action; nevertheless, it is but yesterday that our Western world outgrew the assumption that community of worship or of blood was the sole natural ground of community in political organization. In like manner, we have been taught to believe that the individual is the necessary unit of society, and yet in all archaic societies the family is the only conceivable unit. And so the theory of relationship recognized by our law is apparently the only one which right reason can suggest; yet that theory would have appeared strange and unnatural to an ancient Brahman, or a Roman judge at the time of the Twelve Tables. Thus, "in its leading characteristics," to quote Mr. Hearn, "political, legal, religious, economic, archaic society presents a complete contrast to that in which we live. There was in it no central government, and consequently there were no political organs. There was no law to make, there was none to be executed. There were neither parliaments, nor courts of justice, nor executive officers. There was no national Church. The great bulk of property, not only as to

its tenure, but as to its enjoyment, was in the hands—not of individuals, but of corporate households. There were few contracts, and no wills. Men lived according to their customs. They received their property from their fathers, and transmitted it to their heirs. They were protected, or, if need, were avenged, by the help of their kinsmen. There was, in short, neither individual nor state. The clan, or some association founded upon the model of the clan, and its subdivisions, filled the whole of our forefathers' social life."

Now, how far a knowledge of these things, as taught by comparative jurisprudence, must modify our notions of legal history, is self-apparent. The great mass of speculation in the department of social science has heretofore been uniformly wrong, simply because it never spontaneously entered the modern mind that society was possible without states, kings, parliaments, and positive laws. These elements of modern social life were combined and recombined in numberless ingenious ways in the endeavor to reconstruct the past, but it was never dreamed that they must be absolutely discarded. An organized state, political sovereignty, and sanctioned laws were regarded as essential prerequisites to social existence; and, until the last generation of thinkers, there was not one who contributed a word to the philosophy of history who did not regard the state as the only possible condition of human society. It is easily seen, consequently, why Locke and Hobbes, Rousseau and Montesquieu, and the rest, were hopelessly wrong in their views concerning the origin of the state and the laws. It needed a great change in method to disclose to us their fundamental error; and now that the comparative method of historical induction is established upon a *quasi*-scientific basis, we are in a fair way to rectify century-old misconceptions.

Not the least of the beneficial results which are destined to follow upon the growth of a science of comparative jurisprudence is this, that we shall be taught to realize, more fully than ever before, that all of the phenomena of society, politics, religion, ethics, economics, art, are presented simultaneously by society, and constitute a plexus of interacting causes and effects, independent and yet interpenetrating one another, each of which can only be understood by the light of all.

Two other great lessons this science will be the means of teaching to the world. The first is the exact nature of the relation of custom to law; the second the exact relation of custom and law to legislation. It is obvious that, as the state is a comparatively recent formation, there must have been, as in fact there was, a time when men's conduct was not ruled by anything corresponding to what we know as the law of the state; but it did not, therefore, go uncontrolled. The force which then assumed the place as a rule of conduct which law fills among modern peoples was custom. Now, custom is wholly unlike law as defined by the analytical jurists, in these respects, namely, because first it does not imply a command from any political superior,

and because it is enforced by public opinion rather than by a sovereign political power. While it is thus essentially unlike positive law, it nevertheless "furnishes both the motive and the material for law," and eventually becomes law when the state comes into existence and supplements public opinion with an authoritative sanction. Keller's statement of this is not only so happy, but so perfectly accordant with the fact, as to demand remembrance. "Legal notions," says he, "commence by being instinctively observed in the relations of life, and act upon those relations as a natural force; exactly as is the case in regard to language and manners. But afterward organized human society draws them within the sphere of its conscience and of its freedom of action, and by its creative power gives them a positive form and a determined efficacity." Custom, then, differs from law mainly in the matter of form and sanction, not necessarily in its requirements. The two are, in fact, only earlier and later developments of the same social fact, depending for their evolution upon the play of human qualities in the necessary relations of society.

The second great practical lesson which will be taught by comparative jurisprudence is, as I have said, the knowledge of the true relations of custom and law to legislation. Law is the statical, legislation the dynamical side of the same fact. The lawyer studies what is, the legislator what ought to be. The jurist is he who studies what has been, what is, and what ought to be. The true jurists, the true legislators, will learn from comparative jurisprudence the *lex legum* of which I have spoken; will know the veneration due to those institutions and laws which are the surest exponents of national genius, while they obey implicitly the spirit of progress. Thus they will regard it as a duty to permit no legislation which is not in accord with the genius of the nation, or which would force the law to a hurried or abnormal growth.

And as comparative jurisprudence has borrowed from culture history, so will it pay back its debt to the science of social organization, and demonstrate the eternal absurdity of such schemes as those of Saint-Simon, Fourier, Proudhon, and Louis Blanc; schemes which are not only retrogressive but which contain within themselves a subtile poison hostile to the essential principles of all society. A profound comparative jurisprudence will give the death-blow to "those alchemists of thought," to use the words of Wolowski, "who imagine that society may be made to undergo a transformation between the rising and the setting of the sun."

The great movement of society has been a slow and painful progression from clan society, governed by the law of status, to political society, based upon the principle of individualism; from a society in which individual self-government was unknown, to one which first organized a single central governing power, and which has ever since been limiting that power in favor of the largest practicable individual-

ism. The history of these changes is the history of social progress, of civilization; but it is unintelligible apart from comparative jurisprudence, which is not only the forerunner of a complete science of history, but of the true philosophy of law, which shall rise above all forms and customs, and discover to mankind the generative principle of the just and of the unjust, and make of positive law nothing less than organized justice and right. When that science has been achieved we shall, for the first time, see the real character of that actual law of nature which was undreamed of by Ulpian and Grotius, a law not disclosed to us at the beginnings of society, but only to be disclosed at its end; not while man's possibilities are unfathomed, but when he shall have grown to his noblest nature. Never may we rise to a knowledge of uniform law, uniform justice, until law and justice have manifested themselves to us in perfection, and that will be when their evolution has been completed, not before. The beginning is no nearer nature than the end, for all is nature. Whatever man has been, whatever may be, is due to a larger law, of which positive law is but a part. That law is the true law of Nature, and is knowable only by its manifestations, not by vain guessings as to its character. It can never be wholly known, for Nature discloses herself gradually, and her law will not be made manifest until the end has come.

STATE EDUCATION: A HELP OR HINDRANCE?

By the Hon. AUBERON HERBERT.

FOR ten years we have been busy organizing national education. A vigorous use of bricks and mortar is not generally accompanied by a careful examination of first principles,* but now that we have built our buildings and spent our millions of public money, and civilized our children in as speedy a fashion as that in which the great Frank Christianized his soldiers, we may perhaps find time to ask a question which is waiting to be discussed by every nation that is free enough to think, whether a state education is or is not favorable to progress?†

It may seem rash at first sight to attack an institution so newly created and so strong in the support which it receives. But there are some persons, at all events, whom one need not remind that no external grandeur and influence, no hosts of worshipers can turn wrong

* Has Mr. Leslie Stephen said somewhere, that it is easier to build churches than to think about what is to be taught inside of them?

† I ought to say that I have changed my opinions as regards the action of the state since 1870. I could not have made this change without the assistance of Mr. Herbert Spencer's writings.

principles into right principles, or prevent the discovery, by those who are determined to see the truth at any cost, that the principles are wrong. Sooner or later every institution has to answer the challenge; "Are you founded on justice? Are you for or against the liberty of men?" And to this challenge the answer must be simple and straightforward; it must not be in the nature of an outburst of indignation that such a question should be asked; or a mere plea of sentiment; or the putting forward of usefulness of another kind. These questions of justice and liberty stand first; they can not take second rank behind any other considerations, and if in our hurry we throw them on one side, unconsidered and unanswered, in time they will find their revenge in the imperfections and failure of our work.

National education is a measure carried out in the supposed interest of the workmen and the lower middle class, and it is they especially—the men on whose behalf the institution exists—whom I wish to persuade that the inherent evils of the system more than counterbalance the conveniences belonging to it.

I would first of all remind them of that principle which many of us have learned to accept, that no man or class accepts the position of receiving favors without learning, in the end, that these favors become disadvantages. The small wealthy class which once ruled this country helped themselves to favors of many kinds. It would be easy to show that all these favors, whether they were laws in protection of corn, or laws favoring the entail of estates, creating sinecures, or limiting political power to themselves, have become in the due course of time unpleasant and dangerous burdens tied round their own necks. Now, is state education of the nature of a political favor?

It is necessary, if discussion is in any way to help us, to speak the truth in the plainest fashion, and therefore I have no hesitation in affirming that it is so. Whenever one set of people pay for what they do not use themselves, but what is used by another set of people, their payment is and must be of the nature of a favor, and does and must create a sort of dependence. All those of us who like living surrounded with a slight mental fog, and are not over-anxious to see too clearly, may indignantly deny this; but if we honestly care to follow Dr. Johnson's advice, and clear our minds of cant, we shall perceive that the statement is true, and, if true, ought to be frankly acknowledged. The one thing to be got rid of at any cost is cant, whether it be employed on behalf of the many or the few.

Now, what are the results of this particular favor? The most striking result is that the wealthier class think that it is their right and their duty to direct the education of the people. They deserve no blame. As long as they pay by rate and tax for a part of this education, they undoubtedly possess a corresponding right of direction. But having the right they use it; and, in consequence, the workman of to-day finds that he does not count for much in the education of

his children. The richer classes, the disputing churches, the political organizers, are too powerful for him. If he wishes to realize the fact for himself, let him read over the names of those who make up the school boards of this country. Let him first count the ministers of all denominations, then of the merchants, manufacturers, and squires. There is something abnormal here. These ministers and gentlemen do not place the workmen on committees to manage the education of their children. How, then, comes it about that they are directing the education of the workmen's children? The answer is plain. The workman is selling his birthright for the mess of pottage. Because he accepts the rate and tax paid by others, he must accept the intrusion of these others into his own home affairs—the management and education of his children. Remember, I am not urging, as some do, the workmen to organize themselves into a separate class, and return only their own representatives as members of school boards; such action would not mend the unprofitable bargain. To take away money from other classes, and not to concede to them any direction in the spending of it, would be simply unjust—would be an unscrupulous use of voting power. No, the remedy must be looked for in another direction. It lies in the one real form of independence—the renunciation of all obligations. The course that will restore to the workmen a father's duties and responsibilities, between which and themselves the state has now stepped, is for them to reject all forced contributions from others, and to do their own work through their own voluntary combinations. Until that is done no workman has more, or has a claim to have more, than half rights over his own children. He is stripped of one half of the thought, care, anxiety, affection, responsibility, and need of judgment which belong to other parents.

I used the expression, the forced contributions of the rich. There are some persons who hold that the more money you can extract by legislation from the richer classes for the benefit of the poorer classes the better are your arrangements. I entirely dissent from such a view. It is fatal to any clear perception of justice. Justice requires that you should not place the burdens of one man on the shoulders of another man, even though he is better able to bear them. In plainer words, that you should not make one set of men pay for what is used by another set of men. If this law be once disregarded, it simply reduces politics to a universal scramble, in which the most selfish will have the most success. It turns might into right, and proclaims that each man may rightfully possess whatever he can vote into his pocket. Whoever is intent on justice must be as just to the rich man as to the poor man; and, because so-called national education is not for the children of the rich man, it is simply not just to take by compulsion one penny from him. No columns of sophistry can alter this fact. And yet, when once the obligation disappears, and the grace of free-giving is restored, it is a channel in which the money of the richer classes may most worthily

flow. Whatever the faults are of our richer classes, there is no lack among them of generous giving. Take any newspaper, and you will find that, although by unwise legislation we are closing many of the great channels existing for their gifts, yet the quality persists. The endowment of colleges at one period, the endowment of grammar-schools at another period, gifts to religious institutions, and the support given to that narrow, partial, vexatious, and official-minded system of education which prevailed up to 1870, are all evidence of what the richer people are ready to do as long as you do not withhold the opportunities. It may, however, be said, "Do not rich gifts bring obligations, and with them their mischievous consequences?" It is plain that the most healthy state of education will exist when the workmen, dividing themselves into natural groups according to their own tastes and feelings, organize the education of their children without help, or need of help, from outside. But between obligatory and voluntary contributions there is the widest distinction. There is but slight moral hurt to the giver or receiver in the voluntary gift, provided only that the spirit on both sides be one of friendly eqyality. It is the forced contribution, bringing neither grace to the giver nor to the receiver, which has the evil savor about it, and brings the evil consequence. The contribution taken forcibly from the rich is justified on the ground that the thing to be provided is a necessity for which the poorer man can not pay. Thus the workman is placed in the odious position of putting forward the pauper's plea, and two statements equally deficient in truth are made for him: one, that book-education is a necessity of life—a statement which for those who look for an exact meaning in words that are used is simplu not true; and the other, that our people can not provide it for themselves if left to do so in their own fashion.*

I wish to push still further the question of how much real power the workman possesses over the education of his children. I maintain that, setting aside the interference of ministers, merchants, manufacturers, doctors, lawyers, and squires in his affairs, he has only the shadow and semblance of power, and that he never will possess anything more substantial under a political system. Let us see for what purposes political organization can be usefully applied. It is well adapted to those occasions when somo definite reply has to be made to a simple question. Shall there be peace or war? shall political power be extended to a certain class? shall certain punishments follow certain crimes? shall the form of government be republican or monarchical? shall taxes be levied by direct or indirect taxation? These are all questions which can be fairly answered by Yes or No, and on which every man enrolled in a party can fairly express his opinion if he has once

* At the same time a thorough and radical readjustment of our educational endowments is required in the interest of the workmen, who, though in most cases having the first claim, derive little or no advantage from them.

decided to affirm or deny. But, whenever you call upon part of the nation to administer some great institution, the case becomes wholly different. Here all the various and personal views of men can not be represented by a simple Yes or No. A mixed mass of men, like a nation, can only administer by suppressing differences and disregarding convictions. Take some simple instance. Suppose a town of fifty thousand electors should elect a representative to assist in administering some large and complicated institution. Let us observe what happens. It is only possible to represent these fifty thousand people, who will be of many different mental kinds and conditions, by some principle which readily commands their assent. It will probably be some principle which, from its connection with other matters, is already familiar to their mind—made familiar by preceding controversies. For example, the electors may be well represented on such questions as "Shall the institution be open or closed on Sundays? shall it be open to women? shall the people be obliged to support it by rate? and, when rate-supported, to make use of it?" But it will at once be seen that these are principles which do not specially apply to any one institution but to many institutions. They are principles of common political application—they are, in fact, external to the institution itself, and distinct from its own special principles and methods. The effect, then, will be that the representative will be chosen on principles that are already familiar to the minds of the electors, and not on principles that peculiarly and specially affect the institution in question. Existing controversies will influence the minds of the electors, and the constituency will be divided according to the lines of existing party divisions. Both school boards and municipal government yield an example that popular elections must be fought out on simple and familiar questions. The existing political grooves are cut too deeply to allow of any escape from them.

"But," it may be replied, "as intelligence increases, and certain great political questions which are always protruding themselves are definitely settled, the electorate may become capable of conducting their contests simply with regard to the principles which really belong to the matter itself." Another difficulty arises here. Without discussing the possible settlement of these ever-recurring political questions, it ought to be remembered that, in the case of increased intelligence, we should have an increase in the number of different views affecting the principles and methods of the institution in question; and, as we should still have only one representative to represent us, it would be less possible for him than before to represent our individual convictions. If he represent A he can not represent B, nor C, nor any of those that come after C; that is to say, if A, B, C, and the others are all thinking units, and therefore do not accept submissively whatever is offered to them. He can only represent one section, and must leave other sections unrepresented. But as these individual differences

are both the accompaniment and sign of increasing intelligence, this unhappy result follows, that the more intelligent a nation becomes, the greater pain it must suffer from a system which forces its various parts to think and act alike when they would naturally be thinking and acting differently.

"But if this is so, then there is no such thing possible as representation. If one person can not represent many persons, then administration of all kinds fails equally in fulfilling a common purpose. All united effort, therefore, becomes impossible."

No doubt effective personal representation is under any circumstances a matter of difficulty; but political organization admits only of the most imperfect form of it, voluntary organization of the most perfect. Under political organization you mix everybody together, like and unlike, and compel them to speak and act through the same representative; under voluntary organization like attracts like, and those who share the same views form groups and act together, leaving any dissident free to transfer his action and energy elsewhere. The consequence is that under voluntary systems there is continual progress, the constant development of new views, and the action necessary for their practical application; under political systems, immobility on the part of the administrators, discontented helplessness on the part of those for whom they administer.

"But still there remain certain things which, however much you may desire to respect personal differences, the state must administer; such, for example, as civil and criminal law, or the defense of the country."

The reason why the nation should administer a system of law, or should provide for external defense, and yet abstain from interference in religion and education, will not be recognized until men study with more care the foundations on which the principle of liberty rests. Many persons talk as if the mere fact of men acting together as a nation gave them unlimited rights over each other; and that they might concede as much or as little liberty as they liked one to the other. The instinct of worship is still so strong upon us that, having nearly worn out our capacity for treating kings and such kind of persons as sacred, we are ready to invest a majority of our own selves with the same kind of reverence. Without perceiving how absurd is the contradiction in which we are involved, we are ready to assign to a mass of human beings unlimited rights, while we acknowledge none for the individuals of whom the mass is made up. We owe to Mr. Herbert Spencer—the truth of whose writings the world will one day be more prepared to acknowledge, after it has traveled a certain number of times from Bismarckism to communism, and back from communism to Bismarckism—the one complete and defensible view as to the relations of the state and the individual. He holds that the great condition regulating human intercourse is the widest possible lib-

erty for all. Happiness is the aim that we must suppose attached to human existence ; and therefore each man must be free—within those limits which the like freedom of others imposes on him—to judge for himself in what consists his happiness. As soon as this view is once clearly seen, we then see what the state has to do and from what it has to abstain. It has to make such arrangements as are necessary to insure the enjoyment of this liberty by all, and to restrain aggressions upon it. Wherever it undertakes duties outside this special trust belonging to it, it is simply exaggerating the rights of some who make up the nation and diminishing the rights of others. Being itself the creature of liberty, that is to say, called into existence for the purposes of liberty, it becomes organized against its own end whenever it deprives men of the rights of free judgment and free action for the sake of other objects, however useful or desirable they may be.

It is on account of our continued failure to recognize this law of liberty that we still live, like the old border chieftains, in a state of mutual suspicion and terror. Far the larger amount of intolerance that exists in the world is the result of our own political arrangements, by which we compel ourselves to struggle, man against man, like beasts of different kinds bound together by a cord, each trying to destroy the other out of a sense of self-preservation. It is evident that the most fair-minded man must become intolerant if you place him in a position where he has only the unpleasant choice either to eat or be eaten, either to submit to his neighbor's views or force his own views upon his neighbor. Cut the cord, give us full freedom for differing among ourselves, and it at once becomes possible for a man to hold by his own convictions, and yet be completely tolerant of what his neighbor says and does.

I come now to another great evil belonging to our system. The effort to provide for the education of children is a great moral and mental stimulus. It is the great natural opportunity of forethought and self-denial ; it is the one daily lesson of unselfishness which men will learn when they will pay heed to none other. There is no factor that has played so large a part in the civilization of men as the slow formation in parents of those qualities which lead them to provide for their children. In this early care and forethought are probably to be found the roots of those things which we value so highly—affection, sympathy, and restraint of the graspings of self for the good of others. We may be uncertain about many of the agents that have helped to civilize men, but here we can hardly doubt. What, then, is likely to be the effect when, heedless of the slow and painful influences under which character is formed, you intrude a huge, all-powerful something you call the state between parents and children, and allow it to say to the former : "You need trouble yourself no more about the education of your children. There is no longer any occasion for that patience and unselfishness which you were beginning to acquire, and under the

influence of which you were learning to forego the advantage of their labor, that they might get the advantage of education. We will give you henceforth free dispensation from all such painful efforts. You shall at once be made virtuous and unselfish by a special clause in our act. You shall be placed under legal obligations, under penalty and fine, to have all the proper feelings of a parent. Why toil by the slow, irksome process of voluntary efforts and your own growing sense of right to do your duty, when we can do it so easily for you in five minutes? We will provide all for you—masters, standards, examinations, subjects, and hours. You need have no strong convictions, and need make no efforts of your own, as you did when you organized your chapels, your benefit societies, your trade societies, or your coöperative institutions. We are the brain that thinks; you are but the bone and muscles that are moved. Should you desire some occupation, we will throw you an old bare bone or two of theological dispute. You may settle for yourselves which dogmas of the religious bodies you prefer; and while you are fighting over these things our department shall see to the rest for you. Lastly, we will make no distinctions between you all. The good and the bad parent shall stand on the same footing, and our statutes shall assume with perfect impartiality that every parent intends to defraud his child, and can only be supplied with a conscience at the police-court." This cynical assumption of the weakness and selfishness of parents, this disbelief in the power of better motives, this faith in the inspector and policeman, can have but one result. Treat the people as unworthy of trust, and they will justify your expectation. Tell them that you do not expect them to possess a sense of responsibility to think or act for themselves, withhold from them the most natural and the most important opportunities for such things, and in due time they will passively accept the mental and moral condition you have made for them. I repeat that the great natural duties are the great natural opportunities of improvement for all of us. We can see every day how the wealthy man, who strips himself entirely of the care of his children, and leaves them wholly in the hands of tutors, governesses, and schoolmasters, how little his life is influenced by them, how little he ends by learning from them. Whereas, to the man whose thoughts are much occupied with what is best for them, who is busied with the delicate problems which they are ever suggesting to him, they are a constant means of both moral and mental change. I repeat that no man's character, be he rich or poor, can afford the intrusion of a great power like the state between himself and his thoughts for his children. Observe the corresponding effect in another of our great state institutions. The effect of the poor law—which undertakes the care in the last resort of the old and helpless—has been to break down to a great extent the family feelings and affections of our people. It is simply and solely on account of this great machine that our people, naturally so generous, recognize

much less the duty of providing for an old parent than is the case either in France or Germany. With us, each man unconsciously reasons, "Why should I do that which the state will do for me?" All such institutions possess a philanthropical outside, but inwardly they are full of moral helplessness and selfishness.

These, then, are the first charges that I bring against state education: that the forced payments taken from other classes place the workman under an obligation; that, in consequence, the upper and middle classes interfere in the education of his children; that under a political system there is no place for his personal views, but that practically the only course of action left open to him is to join one of the two parties who are already organized in opposition to each other, and record a vote in favor of one of them once in three years. I do not mean to make the extreme statement that it is impossible to persuade either one party or both parties to adopt some educational reform, but I mean to say that one body acting for a whole country or a whole town can only pursue one method, and therefore must act to the exclusion of all views which are not in accordance with that one method; and that bodies which are organized for fighting purposes, and whose first great object is to defeat other great bodies nearly as powerful as themselves, are bound by the law of their own condition not to be easily moved by considerations which do not increase their fighting efficiency.

I have just touched upon the evils of uniformity in education; but there is more to say on the matter. At present we have one system of education applied to the whole of England. The local character of school boards deceives us, and makes us believe that some variety and freedom of action exist. In reality they have only the power to apply an established system. They must use the same class of teachers; they must submit to the same inspectors; the children must be prepared for the same examinations, and pass in the same standards. There are some slight differences, but they are few and of little value. Now, if any one wishes to realize the full mischief which this uniformity works, let him think of what would be the result of a uniform method being established everywhere—in religion, art, science, or any trade or profession. Let him remember that canon of Mr. Herbert Spencer, so pregnant with meaning, that progress is difference. Therefore, if you desire progress, you must not make it difficult for men to think and act differently; you must not dull their senses with routine, or stamp their imagination with the official pattern of some great department. If you desire progress, you must remove all obstacles that impede for each man the exercise of his reasoning and imaginative faculties in his own way; and you must do nothing to lessen the rewards which he expects in return for his exertions. And in what does this reward consist? Often in the simple triumph of the truth of some opinion. It is marvelous how much toil men will undergo for the sake

of their ideas; how cheerfully they will devote life, strength, and enjoyment to the work of convincing others of the existence of some fact, or the truth of some view. But, if such forces are to be placed at the service of society, it must be on the condition that society should not throw artificial and almost insuperable obstacles in the way of those reformers who search for better methods. If, for example, a man holding new views about education can at once address himself to those in sympathy with him, can at once collect funds and proceed to try his experiment, he sees his goal in front of him, and labors in the expectation of obtaining some practical result to his labor. But if some great official system blocks the way; if he has to overcome the stolid resistance of a department; to persuade a political party, which has no sympathy with views holding out no promise of political advantage; to satisfy inspectors, whose eyes are trained to see perfection of only one kind, and who may summarily condemn his school as "inefficient," and therefore disallowed by law; if in the mean time he is obliged by rates and taxes to support a system to which he is opposed—it becomes unlikely that his energy and confidence in his own views will be sufficient to inspire a successful resistance to such obstacles. It may be said that a great official department, if quickened by an active public opinion, will be ready to take up the ideas urged on it from outside. But there are reasons why this should not be so. When a state department becomes charged with some great undertaking, there accumulates so much technical knowledge round its proceedings that, without much labor and favorable opportunities, it becomes exceedingly difficult to criticise successfully its action. It is a serious study in itself to follow the minutes and the history of a great department, either like the local board or the education department. And, if a discussion should arise, the same reason makes it difficult for the public to form a judgment in the matter. A great office which is attacked envelops itself, like a cuttle-fish, in a cloud of technical statements which successfully confuses the public, until its attention is drawn off in some other direction. It is for this reason, I think, that state departments escape so easily from all control, and that such astounding cases of recklessness and mismanagement come periodically to light, making a crash which startles everybody for the moment. The history of our state departments is like that of some Continental governments, unintelligent endurance through long periods on the part of the people, tempered by spasmodic outbursts of indignation and ineffectual reorganization of the institutions themselves. It must also be remembered that the manner in which new ideas produce the most favorable results is not by a system under which many persons are engaged in suggesting and inventing, and one person only in the work of practical application. Clearly the most progressive method is that whoever perceives new facts should possess free opportunities to apply and experiment upon them.

Add one more consideration. A great department must be by the law of its own condition unfavorable to new ideas. To make a change it must make a revolution. Our education department, for example, can not issue an edict which applies to certain school boards and not to others. It knows and can know of no exceptions. Our bastard system of half-central half-local government is contrived with great ingenuity to render all such experiments impossible. If the center were completely autocratic (which Heaven forbid!), it could try such experiments as it chose; if the localities were independent, each could act for itself. At present our arrangements permit of only intolerable uniformity. Follow still further the awkward attempts of a department at improvement. Influenced by a long-continued public pressure, or moved by some new mind that has taken direction of it, it determines to introduce a change, and it issues in consequence a wholesale edict to its thousands of subordinates. But the conditions required for the successful application of a new idea are, that it should be only tentatively applied; that it should be applied by those persons who have some mental or moral affinity with it, who in applying it work intelligently and with the grain, not mechanically and against the grain. No wonder, therefore, that departments are so shy of new ideas, and by a sort of instinct become aware of their own unfitness to deal with them. If any one wishes to realize why officialism is what it is, let him imagine himself at the center of some great department which directs an operation in every part of the country. Whoever he was, he must become possessed with the idea of perfect regularity and uniformity. His waking and sleeping thought would be the desire that each wheel should perform in its own place exactly the same rotation in the same time. His life would simply become intolerable to him if any of his thousands of wheels began to show signs of consciousness, and to make independent movements of their own.

But suppose that a man of fresh mind and personal energy were to be placed at the head of our education department who perceived the mischievous effect of uniformity, could not this official tendency be counteracted? It might for a short space of time, just as the muscles of a strong man can for some hours defeat the pull of gravitation, but gravitation wins in the end. Such changes would be only spasmodic; they would not be the natural outcome of the system, and therefore could not last. Moreover, for those who understand the value of liberty and of responsibility, it is needless to point out how utterly false the system must be which makes the nation depend upon the intelligence of a minister, and not upon the free movement of the different minds within itself.

I come now to another great evil which accompanies an official system. In granting public money for education you must either give it on the judgment of certain public officers, which exposes you to different standards of distribution and to personal caprice, or you must

give it according to some such system of results as exists at present with us. Payment by results has the merit, as a system, of being simple, easy to administer, and fairly equal; but it necessarily restricts and vulgarizes our conceptions of education. It reduces everybody concerned, managers, teachers, pupils, to the one aim and object of satisfying certain regulations made for them, of considering success in passing standards and success in education as the same thing. It is one long, unbroken grind.* From boyhood to manhood the teacher himself is undergoing examinations; for the rest of his life he is reproducing on others what he himself has gone through. It is needless to say that the higher aims of the teacher, methods of arousing the imagination and developing the reasoning powers, which only bear fruit slowly and can not be tested by a yearly examination of an inspector—whose fly will be waiting at the school-door during the few hours at the disposal of himself or his subordinate—new attempts to connect the meaning of what is being learned with life itself, and to create an interest in work for work's own sake instead of for the inspector's sake, above all, the personal influences of men who have chosen teaching as their vocation, because the real outcome of their nature is sympathy with the young, and have not been drilled into it through a series of examinations owing to some accident of early days, all these things must be laid aside as subordinate to the one great aim of driving large batches successfully through the standards and making large hauls of public money. In our ignorant and unreasoning belief in examinations we have not perceived how fatal the system is to all original talent and strong personality in the teacher. Whether it be a professor at a university or a master in a board school, this modern exaggeration of the use of examinations makes it impossible for him to treat his subjects of teaching from that point of view which is real and living to himself, or to follow his own methods of influencing his pupils. In all cases he must subdue his strongest tastes and feelings, and recast and remodel himself until he is a sufficiently humble copy of the inspector or examiner, upon whose verdict his success depends. Any plan better fitted to reduce managers, teachers, and pupils to one level of commonplace and stupidity could scarcely be found. The state rules a great copy-book, and the nation simply copies what it finds between the lines.

I can not escape a few words on the much-vexed religious question. Under our present system the Nonconformists are putting a grievous strain upon their own principles. Whoever fairly faces the question must admit that the same set of arguments which condemns a national religion also condemns a national system of education. It is hard to pronounce sentence on the one and absolve the other. Does a national Church compel some to support a system to which they are opposed?

* See an article bearing on this point by Mr. Fitch. I have not the reference by me at this moment.

So does a national system of education. Does the one exalt the principle of majorities over the individual conscience? So does the other. Does a national Church imply a distrust of the people, of their willingness to make sacrifices, of their capacity to manage their own affairs? So does a national system of education. Does the one chill and repress the higher meanings, and produce formalism? So does the other. But everywhere Nonconformists are being drawn into supporting the present school system, into obtaining popular influence by means of it, and, what is most inconsistent and undesirable, into using it as an instrument for spreading their own religious teaching. It is rapidly becoming their established Church, and it will have, we may safely predict, the same narrowing effect upon their mind, it will beget the same inability to perceive the injustice of a political advantage, which the national Church has had upon its supporters. Such a result is matter for much regret. First, because there is already but little steady adherence to principle in politics; and where a large body of influential men put themselves in a position which is inconsistent with the application of their own principles there is a sensible national deterioration. Secondly, if school boards are to be instruments of authoritatively teaching subjects of common dispute among us, such as the inspiration of the Bible and the performance of miracles, the struggle between the supporters of revealed religion and the different schools of free-thought must be embittered. It is the question of political advantage and disadvantage which fans these disputes into red heat. Should this be the case, much of the better side of the present religious teaching will be lost sight of by a large part of the nation under the irritation of the political injustice, and its influence lost at a moment when its influence is especially wanted in shaping the new beliefs.

It may be said that secular education will prevent such antagonism, and that every year brings us nearer to the establishment of it. But secular education, even if it be the most just arrangement of trying to meet the injustice which a state system necessarily brings with it, is, at best, a miserable expedient. It is as if everybody agreed by common contract to tie up his right hand in doing a special piece of work in which he was most interested. Far healthier would it be for each section in the nation, from the Catholic to the materialist, to regain perfect freedom, and to do his best to place before children the scheme of life as he himself sees and feels it. If the common argument, that such separate teaching will produce narrowness of mind and sectarian jealousy, is to be regarded, it should be carried a step further, and the children on Sundays should not be permitted to go to their own churches and chapels, but the state should provide a universal temple which ceremonies adapted for all. I confess, for my own part, that I prefer to see intensity of conviction, even if joined with some narrowness, to a state of moral and intellectual sleepiness, and children waiting to be fed with such scanty crumbs as fall from official tables.

It only wants an effort to shake off the thralldom of familiar ideas and to see with fresh eyes, and then the monstrous fact, that all England is placing itself under official restraints as regards that which it cares most about, would be enough to show us that there must be something radically wrong in a system which necessarily carries with it such a disqualification.

"But what are we to do?" is the impatient exclamation of many persons who feel both the pretensions and the poverty-stricken character of our present system. "Could education be supplied without official assistance?" My answer is that it could; that the combining and coöperative power of our people would provide for this great want, as it is providing for their religious and social wants; that money is waiting to flow from some of the richer people, if so plain and good an outlet were left open—money which is at present doing harm by creating scholarships and increasing the power of examinations—that good citizenship essentially consists in those who have learned to value some gift of civilization awakening the same sense in those who remain indifferent. "But why did not education spread quicker in the earlier part of the century?" No truly great thing grows like a mushroom. An intelligent value for education can only spread slowly like civilization itself. In our hurry to act we have not seen how much life and movement is sacrificed to make place for an official system. Those who administer such systems wish to get the flower ready-made without any process of growth. They do not recognize in the early and imperfect efforts the first stage of growth from which the better form will spring, but they wish to start at once with that which will satisfy their own rather prudish eyes. A certain uniform standard is fixed, and all that falls short of it is declared infamous. Of course, it is always possible to smear education, religion, or anything else, over a country, as you might smear paint, by departments or boards, and in five years be able to glorify your great work and to cram your speeches with statistics of what you have done. Every autocrat with ideas in his head has done the same thing, but he has also left it to his successors to moralize over the results of his work. Education when still left to itself did spread, perhaps too rapidly, in the beginning of the century. Presented to the English people by Lancaster, it was received like a gospel of good news; and, although many of the early schools were of exceedingly humble and imperfect form, yet the want was beginning to be felt, and the supply was following. Then came the unwise, if well-intentioned, assistance of Government. As usual, the political philanthropists could not endure to see a movement taking its own direction and shaping itself. As soon as the idea of Government responsibility had taken root, the evil was done. It is a mistake to suppose that Government effort and individual effort can live side by side. The habits of mind which belong to each are so different that one must destroy the other. In the course of time there fell alike

over everybody concerned the shadow of coming changes, and work which would have been done resolutely and manfully, if no idea of Government interference had existed, remained undone, because the constant tendency of Government to enlarge its operations was felt everywhere. The history of our race shows us that men will not do things for themselves or for others if they once believe that such things can come without exertion on their own part. There is not sufficient motive. As long as the hope endures that the shoulders of some second person are available, who will offer his own shoulders for the burden? It must also be remembered that, unless men are left to their own resources, they do not know what is or what is not possible for them. If Government half a century ago had provided us all with dinners and breakfasts, it would be the practice of our orators to-day to assume the impossibility of our providing for ourselves.

And now, leaving much unsaid, I must ask what practical steps should be taken by those workmen who suspect that state education is but a part of that coercive drill which one half the human race delights to inflict upon the other half. First of all, get rid of compulsion. It has been made the instrument of endless petty persecutions. It is fatal to the free growth of an intelligent love of education; to that moral influence which those of us who have learned the value of education ought to be exerting over others; to a true respect of man for man; for each man's right to judge what is morally best for himself and for those intrusted to him. It is an attempt to make one of those short cuts to progress which end by making the goal recede from us. It is an exaggerated idea—as exaggerated, ill-considered, and probably as short-lived as some other ideas of the present moment—of the value of book-education, founded on a rigid and official idea that home duties and labors must in all cases be put aside before the official requirements. It is a copy of a Continental institution, taken from a nation that, living under a paternal Government, has not yet learned to spell the letters of the word Liberty. The example of Germany and its highly organized state education is not alluring. In no country, perhaps, is there less respect of one class for the other class, or greater extremes of violent feeling. Where you subject people to strong official restraint, you seem fated to produce on the one side rigidity of thought and pedantry of feeling, on the other side those violent schemes against the possessions and the personal rights of the rich which we call socialism. Careful respect for the rights of others, vigorous and consistent defense of one's own rights, a deeply rooted love of freedom in thought, word, and action—these things are simply impossible wherever you intrust great powers to a Government, and allow it to use them not simply within a sphere of strictly defined rights, but as supreme judge of what the momentary convenience requires.

Secondly, get rid of all dependence upon the central department. If you do not as yet perceive that public money can not wisely, in

any shape, be taken for education, still refuse the grant that the central department offers as a bribe for the acceptance of its mischievous interference. Until individual self-reliance has grown among us, let each town administer education in its own way. So, at least, we shall get local life and energy and variety thrown into the work, not the mere mechanical carrying out of regulations of two or three gentlemen sitting at their desks at Whitehall. But do not believe that you will get the highest results in this way. More freedom for action and experiment is wanted than you can get under any local board. Accustom yourselves to the idea that men will act better in voluntary groups than if forced into union by external power. Many boards acting freely in a town, and learning gradually to coöperate together to some extent and for some purposes, is what we should look forward to. Perhaps the best step in advance, and in preparation for a purely free system, is to obtain powers from Parliament under which any considerable number of electors, say from one sixth to one tenth, according to the size of the town, might elect, and pay their rate to, their own board. Under such a plan there would be imperfections and possible evasions; but it would cast off the swaddling-clothes imposed by the Privy Council, and would give a life to the work which would far more than compensate for the loss of mechanical regularity. It is always difficult to introduce freedom into a system that is founded on authority and officialism. You can only escape from anomalies and contradictions by being either rigidly despotic or completely free. But a little life and light are worth getting at almost any price, and will make us wish for more. The final step will be to render the rate purely voluntary, and to give full freedom and responsibility of action, for which the people will never be fit as long as they are persuaded to subject each other to official regulations under the much-abused name of self-government.—*Fortnightly Review.*

HOW ANIMALS DIGEST.

By HERMAN L. FAIRCHILD.

IN reception of food, animals have been compared to plants turned outside in. The plant absorbs nourishment by pores in the foliage and rootlets. Higher animals absorb food by similar closed tubes which line a cavity of the body. This interior cavity, the food-tract or alimentary canal, is the most important and the most nearly universal organ of the animal structure. Its purpose is threefold—that of a reservoir, as animals can not always procure their proper food and can not, like plants, be ever eating; a liquefier, as all food, both for plants and animals, must be in the fluid state; and, thirdly, a chemical

laboratory, as nourishment must be like the body in composition. Plants have no need of such an organ, because the food is always at hand in proper condition. Consequently, food is not in the animal body proper when in the stomach. It is within the body, not of the body. It is only dead matter, under the control of the organic forces of the body, and preparing to become a substantial part of the living organism.

The several processes of animal digestion, mechanical, physical, and chemical, are simultaneously performed in varying degree throughout the whole length of the digestive tract. For our present purpose, however, it is more practicable to describe them separately. But that the division is arbitrary should constantly be kept in mind. The main part of mechanical digestion has already been described in the article on "How Animals eat."

Deglutition.—In animals which have the stomach some distance from the mouth or oral aperture, the swallowing of food is a distinct act, requiring special organs. The food must be forced through the connecting tube, known as the œsophagus or gullet. We do not find such in the lowest animals. The whole of nutrition is a single process in the tape-worm; with the amœba, grasping of food is not distinct from digestion; while in the anemone and jelly-fish the mouth opens directly into the stomach cavity.

If the stomach were always beneath the mouth, as in man and birds, food might with some difficulty reach the former by gravity. Birds do help the descent of food by jerking the head, and most birds in drinking lift the head each time the beak is filled. But animals must be able to swallow in spite of gravity, as commonly in eating the stomach is higher than the mouth. This is possible even in man, for the juggler drinks when standing on his head.

Deglutition is accomplished by a peculiar and beautiful involuntary action of the gullet. The walls of this tube are composed of two muscular layers, longitudinal and circular, which act in accord. Immediately in front of the bolus of food the walls are relaxed, while behind and around it the walls contract, thus urging the matter forward; and, "as it travels, the wave of contraction travels with it." This motion of the gullet is well shown in the neck of a horse when drinking. It is a similar action which propels the food through the entire length of the digestive canal—termed in the intestines peristaltic or vermicular motion. The mill-like action of the gizzard and the churning motion of the stomach are only phases of the same thing. By a reversed action of the gullet, the cud of an ox is thrown from the stomach back to the mouth.

To place the bolus of food within reach of the muscles of the gullet, there is in the highest animals a most complex arrangement of parts in the pharynx or back of the mouth. In mammals, the pharynx is a funnel-shaped cavity having seven openings. Here the gullet crosses

the air-pipe; and, to keep food and drink from taking the wrong road, there is an effective system of valves. The parts act spasmodically whenever they are irritated by the pressure of solids and liquids.

Saliva is found in nearly all animals. Its universal office is to lubricate the food and so help it to glide easily along the pharynx and

FIG. 1.—MEDIAN ANTERO-POSTERIOR SECTION OF THE HUMAN FACE: *a*, septum of nose, with section of hard palate below it; *b*, tongue; *c*, section of soft palate; *d*, *d*, lips; *u*, uvula; *r*, anterior arch, or pillar of fauces; *i*, posterior arch; *t*, tonsil; *p*, pharynx; *h*, hyoid bone; *k*, thyroid cartilage; *n*, cricoid cartilage; *s*, epiglottis; *v*, glottis; 1, posterior opening of nares; 3, isthmus faucium; 4, superior opening of larynx; 5, passage into œsophagus; 6, orifice of right Eustachian tube.

gullet. This kind of saliva is a glairy mucus, and is the only kind in animals which do not chew the food—for example, birds, reptiles, and fishes. As an aid to digestion, the saliva of mammals will be considered later.

The most astonishing feats in swallowing are performed by the snakes. The boa can certainly swallow a goat or deer. Our common little snakes, the size of a finger, can swallow a large frog, a performance sufficiently remarkable. The process is very slow and tedious, and one would suppose painful. The boa first kills its prey by crushing it in its tightening coils, which break down the ribs and limbs and reduce the victim to a shapeless mass. By this horrible proceeding the carcass is gotten into condition to be more easily swallowed. After coating it with mucus, the boa begins the difficult operation of forc-

ing the huge mouthful down its throat. But how shall the act be accomplished with no limbs to assist? As the under jaw divides in front, and articulates with the skull by the intervention of extra movable bones, the mouth and throat can stretch enormously. The sharp, conical teeth are recurved, acting like the barb of an arrow to hold whatever position is gained. Each side of the jaw is pushed forward in turn and gains a new and further hold on the carcass, which by successive slight movements is slowly pulled head first down the gullet. The common striped snake seizes a toad or frog, however he can catch him, usually by one or both hind legs, and immediately proceeds to "take him in," despite all protests and struggles.

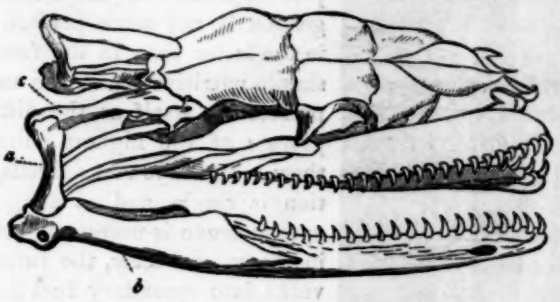

FIG. 2.—SKULL OF A SERPENT (*Python*): *b*, articular portion of the lower jaw; *a*, quadrate bone; *c*, squamosal portion of the temporal bone.

As the opposite of the enormous throat of the snake, the bulky whalebone whale has the smallest throat, proportionate to its size, of any animal—just large enough to admit the tiny creatures which are its food. We see in this a fine example of Nature's economy.

The alligator has a curious way of preventing the admission of water when swallowing prey. Seizing a fish or other small creature, the reptile rises to the surface of the water and flings it into the air; then, before it reaches the water, catches it and gulps it down. If the prey is too large to handle in this manner, it is carried to the shore to be devoured.

INGLUVIATION.—Many animals can not procure their particular food at all times. Such either can endure fasting, like members of the cat tribe, or have a special reservoir, as shown in the crop of a fowl. This crop is only a dilatation of the gullet. In the cormorant, the whole gullet is very capacious, for the purpose of storing fish; on account of which habit the bird has become a type of voracity. The pigeon has its crop divided into two—perhaps to give a better form for flight. The pelican has a bag beneath the lower jaw. Many small animals, insects especially, have crops. Similar in purpose is the first stomach, or paunch, of a cud-chewer. Birds which eat fruit, insects, or other food readily procured, and of a character which needs no delay in digestion, have usually no crop, or but a rudimentary one.

While the whole digestive tract serves the purpose of a reservoir, the special reservoirs have indeed a digestive function, serving to delay the food, that it may be acted upon for a sufficient time by the chemical fluids. Thus the crop of a bird secretes a fluid which softens and prepares the hard grain for subsequent trituration and digestion.

ORGANS OF CHEMICAL DIGESTION.—As the organ of digestion proper is the one most nearly universal, it consequently affords the finest example of specialization and development. From the improvised cavity of the amœba, there is a steady progress by minute steps to the complex apparatus of the mammals. Digestion is not more perfect, however, in the latter than in the former. The simple nutritive act of the amœba is as perfect for itself as the differentiated process of the highest animals is for them. In the lowest animals, the function is single, and so simple that no special organ is necessary. As we rise in the animal scale, the function is divided into secondary functions, which require for their performance a corresponding number of special organs. Indeed, the complex functions of prehension, mastication, digestion, and circulation are only subdivisions of nutrition which begins in the lowest life as a single act. The present purpose, however, is not to trace the evolution of specialization of the digestive function further than to illustrate its general principles and methods, and present some of its peculiar and interesting features.

FIG. 8.—*Tænia solium*, OR SOLITARY WORM: *a*, head, or scolex; *b*, tape formed of many individuals, the last of which, completely sexual, separate under the name of *proglottides*, and represent the adult and complete animal. Each solitary worm is a colony.

The tape-worm has no digestive organs whatever, having no use for them. A robber subsisting on the labors of its victim, it takes food in the same manner as a plant, by absorption from the outside. This is also the case with many lower protozoa.

The digestion of the amœba is only one remove higher than that of the tape-worm—with no permanent organs, but extemporizing a stomach from the skin as required. A step higher still we find the hydra, with a permanent body cavity serving the purpose of a stomach. But it is not distinctively a stomach, as it is the common organ

of all the other vegetative functions. A single opening serves both to receive the food and expel the waste matter. Within even this narrow limit of structure, we find a host of low animals which exhibit a great variety of forms; so that from the hydra to the ctenophore is a progressive series showing a gradual specialization of this common

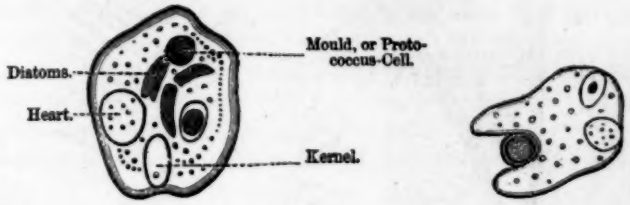

FIG. 4.
POND-AMŒBA DIGESTING ITS FOOD. AMŒBA EATING.

organ. In the higher part of the series, as for example the sea-anemone, there is a digestive cavity somewhat separated from the body cavity, though still connecting; and all the excretions have to find their way out through the oral aperture.

In the compound hydrozoans, produced by budding and division, such as sertularia and the so-called corals, the body cavity is continuous through the whole community. Hence each individual (though

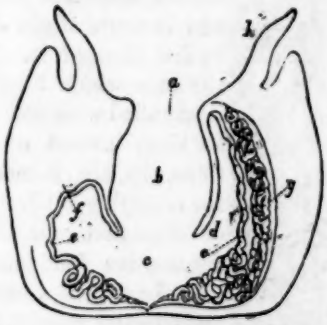

FIG. 5.—PERPENDICULAR SECTION OF *Actinia holsatica* (after Frey and Leuckart): *a*, mouth; *b*, gastric cavity; *c*, common cavity, into which the gastric cavity and the intermesenteric chambers open; *d*, intermesenteric chambers; *e*, thickened free margin, containing thread-cells of, *f*, a mesentery; *g*, reproductive organ; *h*, tentacle.

it is scarcely correct to regard it as such) has its stomach connected with the stomachs of all the others. Whatever food one digests serves to nourish the whole colony. They are absolute communists.

At this point should be presented the fact that in all animals the lining or secreting membrane of the food-canal is essentially but a continuation of the skin. That such is true of the amœba is evident, for what was the outside of the body-mass becomes when food is enveloped the lining of the new cavity. The cup-shaped body of the hydra can

be turned inside out without interference with the business of digestion. The skin in these cases must have a chemical digestive power,

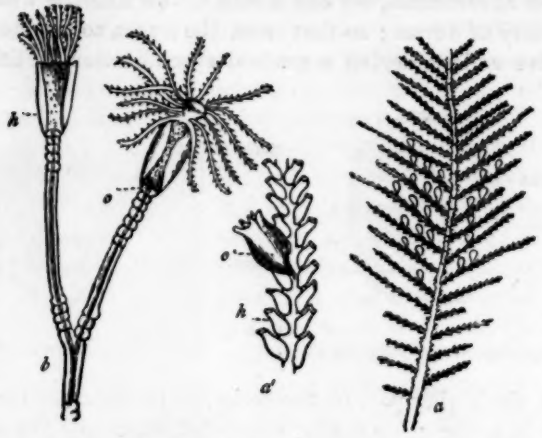

FIG. 6.—*a*, *Sertularia* (*Diphasia*) *pinnata*, natural size: *a'*, fragment of the same enlarged, carrying a male capsule (*a*), and showing the hydrothecæ (*h*); *b*, fragment of *Campanularia neglecta* (after Hincks), showing the polypites contained in their hydrothecæ (*h*), and also the point at which the cœnosarc communicates with the stomach of the polypite (*o*).

as the food taken in mass, and frequently living substance, or even whole animals, is dissolved without trituration or mechanical aid. The human skin has powers of absorption, and in some slight degree a person may be fed through it. The continuation of the skin which lines the digestive canal is supplied with new powers of secretion; so that, instead of producing perspirations, oils, etc., it manufactures chemicals for changing food. Hence the principle of digestion and the character of the organs are fundamentally the same in all animals, the lowest with the highest. Only in the amœba, hydra, etc., digestion is accomplished with the least possible expenditure.

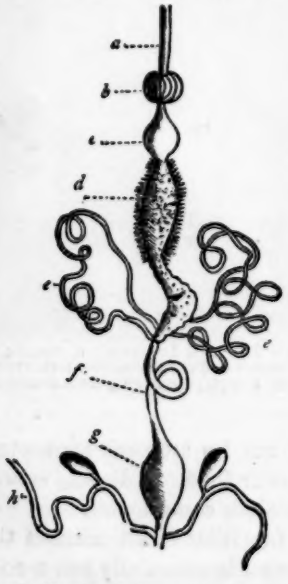

FIG. 7.—DIGESTIVE SYSTEM OF A BEETLE (*Carabus auratus*): *a*, œsophagus; *b*, crop; *c*, gizzard; *d*, chylific stomach; *e*, Malpighian tubes; *f*, intestine; *g*, cloaca; *h*, supposed renal vessels.

A *true stomach* must be wholly devoted to the elaboration of food, leaving other functions to other organs. This requires that it be wholly shut off from other cavities of the body; and it were better to have two openings, one for reception of food, the other an outlet for waste matter, in order to give the food a single direction and prevent the mingling

of digested and undigested matter. This perfect stomach is realized so gradually, or by such slight degrees, in a large number of lower animals, that it is not easy to say positively which animal has the honor of its first possession. To the little sea-urchin, which is the first possessor of true teeth, is generally given the credit. The ctenophore, a lower animal, has indeed two or more apertures to its food-cavity, but the mouth is still the main excretory orifice, and this cavity freely communicates with a system of body canals. The starfish, on the contrary, has the stomach distinct from the other cavities of the body, with, however, in most cases only a single opening.

In the sea-urchin we also find an intestine and indications of the several parts which are so distinct in higher animals. The sea-cucum-

FIG. 8.—DIGESTIVE SYSTEM OF THE COMMON FOWL (after Owen): *o*, gullet; *c*, crop; *p*, proventriculus; *g*, gizzard; *sm*, small intestine; *k*, intestinal cæca; *l*, large intestine; *cl*, cloaca.

ber, a near relative of the former but with a better digestive canal, is almost as highly favored regarding its stomach as the low amœba. If its stomach becomes troublesome from indigestion or other cause, it simply ejects it through the mouth, along with its other internal organs. Then it quietly awaits the growth of a new set—certainly a very happy and efficient method. Many human dyspeptics would rejoice in the same power. This animal is said to reject its viscera when it is injured or alarmed. This is interesting, as showing in the low animals that which is well known in the highest, the immediate effect of fear and pain upon the internal organs, or the close dependence of the nutritive organs upon the nervous system.

Among articulates and mollusks we find a great diversity in the character of the digestive canal. Its main divisions are always shown

more or less distinctly. But in many articulates, as some worms, myriapods, larvæ of insects, and crustaceans, the tube is quite straight; while in others it is highly convoluted. Biting insects have all the parts ever found in the food-tract, namely, pharynx, gullet, crop, gizzard, stomach, small and large intestines. In some members of the spider family, the short and straight food-canal sends off branches into the limbs and other members. The absurdity of a creature carrying its stomach in its legs!

Many snails have crop and gizzard, as also has the nautilus. In snails the intestine passes through the liver, and in clams through the heart. Many butterflies take no food, and the digestive organs are entirely absent. In this case the eating and storing of nutriment was performed in the earlier larval state with excellent organs. But the male notommata, one of the rotifers, never has digestive organs; it lives its brief life upon the nourishment of the egg from which it was derived.

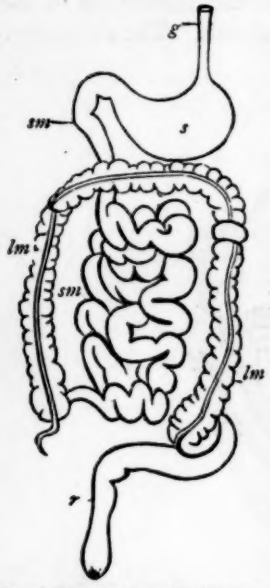

FIG. 9.—DIAGRAM OF THE DIGESTIVE SYSTEM OF A MAMMAL: *g*, gullet; *s*, stomach; *sm*, small intestine; *lm*, large intestine; *r*, rectum, terminating in the aperture of the anus.

Fishes have a short and comparatively simple alimentary tube with generally a wide gullet, and seem commonly to disgorge indigestible substances. Reptiles usually have the parts more strongly marked. Tadpoles have a very long and greatly convoluted canal, but the vegetable-eating turtles have the longest. Crocodiles have a powerful gizzard, like birds, and are said to swallow stones to assist the trituration of food. They approach birds also in possessing a mesentery, a membrane which supports the food-tract and fastens it to the walls of the body. In all lower animals the canal lies loosely in the body cavity. The food-tract of birds varies in length and character according to the kind of food. The crop and gizzard have already been described, the latter in a former article.

In mammals the great body cavity is divided into two chambers, thorax and abdomen, by a transverse partition called the diaphragm. The gullet passes through and the stomach lies just beneath this membrane. The parts of the food-tract are always clearly marked, and the stomach is frequently divided. In all animals digestion is more prolonged in proportion as the food is unlike animal substance. With carnivorous mammals the process is simple. The whole length of the food-tract in members of the cat tribe is only about three times the length of the body. Man employs a mixed diet, and has the canal six times the length of the body. No food is less like flesh than herbage,

consequently we find with such food the most difficult digestion. In ruminants the canal is over twenty times the length of the body; and the stomach is divided into four chambers, to delay the food and complete the mechanical process. The first two, however, are more properly expansions of the gullet. The first chamber, called the *paunch* or *rumen*, stores and moistens the half-chewed food. This division in the camel has a portion lined with cells for storing water. The second chamber, known as the *reticulum* or honey-comb stomach, receives this raw material, rolls and presses it into separate balls, which are sent up to the mouth for more perfect mastication. When this is complete, the now semi-fluid or pasty bolus, being unable to distend the aperture to the first and second chambers, flows into the third chamber. This has its lining greatly folded in order to detain coarse material, whence it is called *manyplies* or *psalterium*. The fourth chamber,

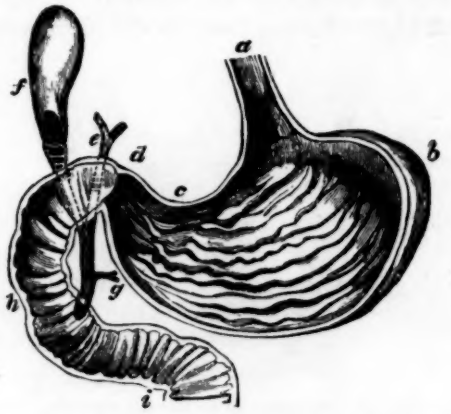

FIG. 10.—THE STOMACH LAID OPEN BEHIND: *a*, the œsophagus; *b*, the cardiac dilatation; *c*, the lesser curvature; *d*, the pylorus; *e*, the biliary duct; *f*, the gall-bladder; *g*, the pancreatic duct, opening in common with the cystic duct opposite *h*; *h*, *i*, the duodenum.

abomasum, is the stomach proper, as here alone is the food subjected to the gastric juice.

On account of defective mastication, the whales have at least three divisions of the stomach; many mammals have two divisions; and the toothless ant-eater has a gizzard.

DIGESTIVE FLUIDS.—After considerable investigation, the precise action of the several fluids which accomplish the chemical change of food is yet unknown. Indeed, their general function is still a matter in discussion. Naturally, then, our knowledge of the functions of the accessory digestive organs in the lower animals is limited. That digestion, however, in all animals is the result of chemical action under the influence of vital force seems assured.

Of the several fluids or chemical agents prepared within the laboratory of the digestive apparatus, the most important and indispensable

is the gastric juice, the presence of which determines the location in the food-tract of the stomach proper. This is because the fluid is produced by the lining of the stomach, and not by a distinct organ. That even the microscopic animals have some digestive fluid, like gastric juice, is regarded as proved by the fact, already noticed, that solid food is dissolved by them without mechanical aid. This fluid is well shown in the radiated animals. Its active principle is a ferment called *pepsin*, which acts only in the presence of an acid. The acidity of the fluid is given by free hydrochloric acid. Gastric juice dissolves only nitrogenous substances, as meat, albumen, and gelatine, having little or no effect on oil or starch.

Next to the gastric juice in importance, if we may judge by its early appearance in the animal kingdom, is the bile. This alkaline fluid is found in all animals having a distinct digestive cavity. The earliest biliary organs are minute cells upon the stomach-lining, as in the anemone. A higher form is found in the small tubes surrounding

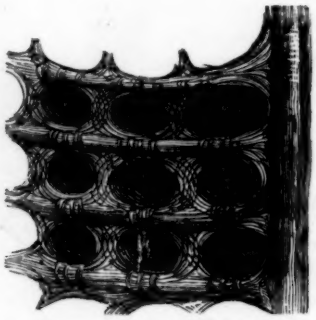

FIG. 11.—WATER-CELLS OF CAMEL'S STOMACH.

the intestines of the insect, from which there are slow gradations to the superior liver of the higher mollusks and fishes. In the articulates, mollusks, and all higher animals, the bile is poured into the intestine and so separated from the gastric juice. The action of the bile is not fully known; but it appears to dissolve fats slightly, and helps to subdivide them into minute particles which are "diffused through the liquid like atoms of butter in milk." It probably aids also in the process of absorption.

The pancreatic juice, another alkaline fluid, is found below the vertebrates only in the higher mollusks. As a gland the pancreas is rudimentary in the cephalopods, but appears better developed in the fishes, and proportionally largest in birds. The function of this fluid is a general one, as it acts on nearly all aliments, and seem to be the principal means of digesting oils and starch, or carbonaceous foods. It is poured into the small intestine near the stomach.

By the mucous lining of the intestines there is produced an alkaline

fluid or fluids which are supplementary to the former. Thus we find digestive fluids secreted through the whole length of the food-canal.

Saliva is present in most animals as a lubricant for the food. But in those animals which chew the food there occurs another kind of saliva, a limpid fluid which aids mastication by softening the food. In mammals this has also a chemical power, changing starch to sugar. As the latter substance is heat-producing, this chemical energy is lacking in the cold-blooded vertebrates. In birds this saliva is replaced by the abundant pancreatic juice. It is most abundant in herbivores, as might be supposed from the fact that starch is a vegetable product.

ABSORPTION.—The dissolved and chemically altered food is yet to be taken into the body, and carried wherever needed, either to supply deficiency or produce growth. At present we have to do only with the first process. In some degree the food is absorbed, as fast as digested, by blood-vessels through the whole alimentary tract. This is true particularly of the stomach. But in vertebrates absorption is

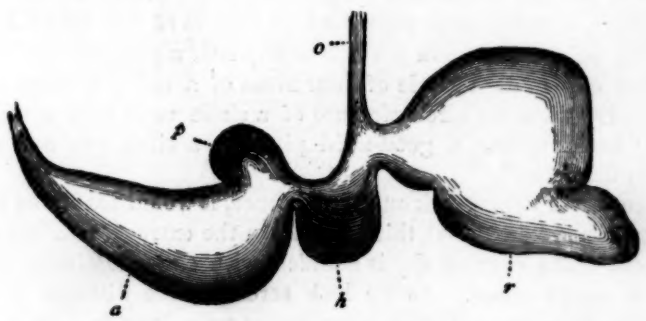

FIG. 12.—STOMACH OF A SHEEP; *o*, gullet; *r*, *rumen*, or paunch; *h*, honeycomb-bag, or *reticulum*; *p*, manyplies, or *psalterium*; *a*, fourth stomach, or *abomasum*.

chiefly by minute tubes, called lacteals, which line the intestines. After passing through certain glands, these tubes unite to form a single tube known as the thoracic duct, which pours its contents into the veins in the neck.

In the higher invertebrates the blood-vessels take up all the nutriment directly from the digestive canal. In the lower, the food as fast as digested passes directly through the walls of the canal into the tissues; while in the lowest animals, where the digestive cavity communicates with the body cavity, the food freely bathes all parts of the structure. Simpler still, in the case of the tape-worm absorption is all the creature has to do.

Whether the process of absorption is wholly physical or partly vital is disputed. But some time during the process, or immediately afterward, the food is changed from merely dead substance to vitalized organized matter, and it is now ready to form part of the living tissues.

THE SOLAR SYSTEM AND ITS NEIGHBORS.*

By C. B. WARRING, Ph. D.

ASTRONOMERS say that this world of ours, which seems to us so large, is in fact so small in comparison with the sun and stars, that its presence or absence is, to the universe, a matter of inconceivably small importance; and that, even in its own system, it would hardly be noticed by an eye capable of taking in at one view the sun and its attendant planets.

Sir John Herschel gives the following illustration of the size and distance of these bodies: "Choose," he says, "any well-leveled field. On it place a globe two feet in diameter; this will represent the sun; Mercury will be represented by a grain of mustard-seed on the circumference of a circle 164 feet in diameter for its orbit; Venus, a pea in a circle of 284 feet in diameter; the earth, also, a pea on a circle of 430 feet; Mars, a rather large pin's head in a circle of 654 feet; Jupiter, a moderate-sized orange in a circle nearly half a mile across; Saturn, a smaller orange on a circle of four fifths of a mile; Uranus, a full-sized cherry upon the circumference of a circle more than a mile and a half; and Neptune, a good-sized plum on a circle two and a half miles in diameter."

If our earth were struck out of existence, it would hardly be missed from such a system. But this is far from the extreme measure of our littleness. The evening sky is studded with stars. Between us and them is empty space. As we look across it, the distance does not seem so very great, and even astronomers were long in learning how great it is, and how utterly isolated the sun with its train of planets is from even the nearest star. Keeping the same scale as before, in which our inconceivable distance from the sun, 92½ millions of miles, was reduced to a dozen rods or so, and then setting out to visit our neighbors, if we are lucky enough to turn our steps to the nearest, we find before us a journey of nearly 9,000 miles. Had we directed our course to any other of the stars, our road would have been many thousand miles longer. There are stars from which light requires 6,000 years to reach our globe!

Had we gone toward one of them, our journey on the same infinitely reduced scale would have taken us nearly 18,000,000 miles before reaching our goal.

Even this scale gives distances too vast. Let it be changed. Let the sun shrink to a point $\frac{1}{100}$ of an inch in diameter. The distance to the sun, 92½ millions of miles, would be reduced to nearly one inch. The earth would be only $\frac{1}{10000}$ of an inch in diameter, requiring

* Read, January 13, 1880, before the Poughkeepsie Society of Natural Science.

1,000,000,000,000 times its bulk to make a globe one inch in diameter. On such a scale our world would be equaled in minuteness only by the animalcules which the microscope reveals. Even then, on this inconceivably reduced scale, the line that would reach our nearest neighbor would need to be something more than three miles long.

Yet that sun, which in this estimate we have mentally reduced to a point $\frac{1}{100}$ of an inch in diameter, is in reality a body so vast that, were it hollow, and our earth placed at its center, the moon would not only revolve freely around our planet, just as it now does, but on every side the sun would extend more than 200,000 miles beyond the lunar orbit. We have heard so often of the distance from here to the sun, 92½ millions of miles, that we begin to think we have some idea of its inconceivable greatness. Yet, so large is the sun that only 107 such bodies, laid so as to touch each other, would be needed to form a continuous bridge from the earth to that luminary. In the sky it appears so small that we find it difficult to realize that scarcely more than 100 times its diameter would reach so far.

However many of us may have sought, by these or by other illustrations, to form some conception of the vastness of the universe, but few have attempted to grasp the measure of that power which compels the planets to move in elliptical orbits instead of flying off in tangents, as, if left to themselves, they would inevitably do; and still fewer have thought of the force with which these bodies tend to pull one another out of their courses. Of these influences astronomers have given no illustrations, yet their contemplation will lead to results that will enlarge our views of the universe, and help us to rise at least a little toward a conception of Omnipotence.

We must work out our conclusions ourselves. The data are all at our hand. We need only to know the distances and masses; the rest is a matter of easy computation. But that our results may not be meaningless from their very greatness, it will be wise to follow the method which we pursue when trying to get an idea of great distances. We take first some unit with which we are familiar—for instance, a mile—and think how many miles it is to some place familiar to us. Then we extend that measure, or some multiple of it, to another place more remote, and then to one still more distant; and thus by degrees we become able to grasp distances whose statement in figures had previously conveyed little or no meaning to our minds. So, in measuring a force, we get a better idea of its greatness if we work up to it in a similar manner.

Of all known substances steel is the most tenacious. If the interplanetary forces can be represented by steel bars of known size, it will at least help to bring them within the limits of our comprehension.

Philosophers have found that a steel wire one tenth of an inch in diameter will support nearly half a ton, while a bar one inch square will not be pulled asunder by less than sixty tons. If two inches

square, it will require 240 tons; if three inches square, it will scarcely break with 540 tons. Bars of steel are not often made larger than this, although Krupp, in his colossal works, doubtless makes some whose section equals 144 square inches. To pull apart such a bar would require a strain equal to the weight of 8,640 tons. It requires an effort to grasp the meaning of such a load. A stout team will haul two tons over a good road for a moderate distance; that number of tons would require more than 4,000 such teams to move it. If put upon a railroad it would need 864 cars and twenty-three locomotives to draw it. It would equal in weight one of the largest ocean-steamers with its complement of freight.

But we shall need a much larger unit than this. Could a bar of steel three feet square be forged—and, judging from the size of his steel cannon, Krupp might do this also—it would be able to lift nine times that great amount. Probably no furnace can much exceed this, but we may imagine a monster bar measuring one rod—16½ feet—square, and by easy multiplication we find its strength great enough to lift 30¼ times as much as the last, or in figures 2,352,240 tons, three times the weight of the cotton crop of the United States when it equaled 4,000,000 bales.

To get a fit unit for our purpose we shall need to go far beyond this, but first pause to contemplate a bar of steel 16½ feet square. As it lay stretched upon the ground, we would need a ladder to get upon its upper side. Few rooms in private dwellings are 16½ feet high, and 16½ feet wide makes a spacious parlor.

Endeavor to get some idea of its tenacity, and how many million horses it would require to pull it asunder, and then, after getting somewhat accustomed to the greatness and strength of a bar of solid steel 16½ feet square, imagine one which is one mile square—5,280 feet wide, and as many thick. If it lay on the ground near the Catskill Mountains, its upper surface would overtop their highest summit by more than 1,000 feet. It would be equal to 102,400 such monster bars as the last. Its lifting power would be nearly 240,869,000,000 tons. The mind is utterly unable to grasp such figures. The whole globe contains 1,200,000,000 inhabitants. If each man, woman, and child, could pull with a force of 100 pounds—a large estimate—to move such a weight would require the united efforts of the inhabitants of two thousand such worlds as this.

As I shall have frequent occasion to speak of the load which such a bar could sustain, I shall, for convenience, call it in round numbers 240,000,000,000 tons, neglecting the other figures, because the number is so inconceivably great that taking from it a billion or so of tons will alter the result less than one half of one per cent. This bar is to be the unit of measure which I shall for the present employ, and with its help I shall attempt to give some idea of the influence of the sun in holding the system together, and of the attraction exerted by the

planets upon our earth, and by the earth upon the moon; and, lastly, by the fixed stars upon the sun and upon each other.

We begin with the moon because it is nearest to us, and, with the exception of the sun, is to us the most important of all the heavenly bodies.

If a half-dozen persons were asked how large the moon appears, they would give as many different replies: "The size of a cart-wheel"; "Twelve inches across"; "The size of a dining-plate"; "As big as a man's head," etc. Probably no one would mention a smaller measure, yet a cherry held at arm's length much more than covers its disk. It is difficult to believe that so small a body exerts any considerable influence on the earth which seems so immensely larger. It is easy enough to admit that the earth holds the moon in its orbit; but, that to do this, to bend its course into a nearly circular orbit, requires any great outlay of force, is not so clear. Our credulity would be taxed were we asked to believe that the moon in its efforts to move in a straight line would break away, although held by a bar of steel one foot square, for that means a force able to lift nearly 9,000 tons. An astronomer would grant it, making first a mental calculation to see if he were justified in doing so; but even he would hesitate, and perhaps would deny that it was possible the moon could pull asunder one of those great unit-bars one mile square, and equal to more than 27,000,000 bars each one foot square.

But he would have no hesitation in saying, "Impossible!" if told that, rather than change its course from a straight line to its present curve, our willful little satellite would snap like pack-thread not one, nor two, nor three of those unit-bars, but the united strength of 10,000—or, in other words, one gigantic bar whose section is 100 miles square. Yet, more than eight such bars, or, more precisely, 87,500 unit-bars, would but barely deflect the moon into its present path.*

You will say, "This is too much—no one will believe it!" Let us see. A few astronomical facts, with a very small amount of mathematics, will suffice to show that there is no exaggeration here. One need know only the weight of the earth and moon, and their distance apart, and the law that gravitation grows less as the square of the distance increases, and he has all the elements required for the calculation.

The weight of the earth is found by an experiment described in almost every school philosophy. It consists in comparing the attraction exerted by a ball of lead of known weight with that exerted by the earth. In this way the earth's weight has been ascertained to

* The non-astronomical reader may, perhaps, need to be reminded that the moon does not move easily and naturally in a circle—or ellipse—but that its path, if left to itself, would be a straight line—a tangent to its orbit. Consequently, the moon requires to be forced into a curve.

be in round numbers 6,000,000,000,000,000,000,000 tons, or, as it is more conveniently written, 6×10^{21}, where the 21, of course, denotes the number of ciphers after the 6. The moon's mass is nearly one eightieth ($\frac{1}{81}$) as great, or, in other words, if it lay upon the surface of the earth, it would weigh 75,000,000,000,000,000,000 tons (75×10^{18}). This, however, must be diminished because the moon is, in fact, sixty times farther off, measuring in both cases from the center of the earth. Dividing, then, the moon's weight by the square of 60, or 3,600, we have for the weight at its actual distance something more than 21×10^{15} (21,000,000,000,000,000) tons after adding one eightieth for the attractive power of the moon itself, for there is a mutual attraction.

To get, then, the number of unit-bars necessary to equal this effect, we have only to divide the weight of the latter by the amount which one of these bars will sustain. That is, we divide 21×10^{15}, by 24×10^{10}, and find the quotient to be 87,500, which agrees with our statement.

It will be interesting to stop here, and endeavor to get some faint idea of what these enormous numbers mean. A bar of steel whose section is 87,500 square miles would include within its four sides a territory as large as that of New York State, and still leave enough to cover the State of Ohio, with a surplus of 536 square miles for good measure. We read in a certain book of a traveler who, coming into Lilliput, was held immovable by thousands of tiny threads. If a web of steel were stretched from the earth to the moon to hold our satellite from flying off into space, each tiny thread being represented by a bar of steel one fourth of an inch square—no trifle, for each could hold 7,500 pounds—they would cover our globe on the side toward the moon with a network whose threads would be only six inches apart, and through which none but the smallest animals could pass.

It may aid us, while seeking to grasp such a force, if we reflect that the very small difference between the moon's pull upon the ocean and that upon the earth's center suffices to lift the tides; how vast, then, must be the whole pull upon the earth!

All this inconceivably great force is needed to bend our satellite's course from the straight line in which it would move if left to itself. This force is exerted, not once for all, as in case of the original impulse that sent the moon forward in its path, but afresh every second; for otherwise, after such an indrawing, it would move thenceforth in a straight line. To give a circular orbit, the direction of the moon needs to be changed every moment, and this requires a series of impulses.

Thus much for our earth's satellite. We may extend our reasoning to more distant bodies. The earth is 81 times the mass of the moon; the sun is 315,000 times the mass of the earth, and something more than 381 times as far from it as we are from the moon. Combining these in an easy calculation, we find that the sun puts forth upon our earth a coercive force to bend its path into an ellipse, a force

to be measured by 15,000,000 of our unit-bars, together making a bar of solid steel whose section would cover 15,000,000 square miles, more than four times the area of the United States. The wires, such as we supposed to hold the moon, would, in the case of the earth and sun, be almost as close as the blades of grass on a lawn.

Without going any further into calculations, it is enough to say of the other planets, that Mercury is held to its duty by 6,590,000 of our unit-bars; while Venus, being nearly as large as the earth, and so much nearer the sun, requires the united strength of nearly 23,000,000. Mars is smaller, and more remote, and therefore needs only some 811,500 such bands to hold it to its course; for, strange as it may appear, and however unlike other sovereigns, the sun holds its subjects in obedience the more easily, the greater their distance from the center of the system, provided, of course, that their importance otherwise is the same. But still, distant as it is, Jupiter's immense mass demands incomparably the strongest measures to keep it in check; nothing less than 170,000,000 of those bands of steel will overcome its wandering tendencies. Saturn, being a lighter weight, is more easily guided—15,000,000 suffice for that. Uranus and Neptune are of little account as compared with Jupiter; 588,000 for the one and 282,000 for the other are all that are needed to restrain their vagaries.

If, now, we turn to the planets, and study their influence, we shall find them pulling and tugging at each other with forces that, but for compensations planted in the system itself, would tear it to pieces; but, like the armed men of Cadmus, these forces destroy each other.

However difficult it may be to conceive of such an amount of power as the sun puts forth, we are so accustomed to regard that body as the governing center of our part of the universe, and have heard so much of its vast size, that we are prepared to accept almost any statement in regard to it. But as to the planets we do not realize their size, and we seldom think of their exerting any influence on the earth or on one another. That they do exert such an influence we know, for astronomers have told us of perturbations thus produced; but, then, very few of us connect such statements with the tiny specks which we see in the heavens. Yet their influence is no trifle. Mercury, which is too small and too near the sun for most of us to have seen, draws the earth when in mean perigee with a force small indeed when compared with those which we have been considering, but large enough to break 232,390,000 bars one foot square; Venus pulls with a force of 11,175,000,000; Mars pulls enough to overcome the united strength of 590,680,000; while Jupiter draws away with a steady tug of nearly 23,000,000,000; and even Neptune, 2,700,000,000 miles away, and utterly invisible to the naked eye, still has sufficient energy to drag our earth toward it with force able to snap 27,000,000 such bars. Besides these, which are only the interplay of forces between our

globe and its sister planets, a similar action is constantly going on between each planet and all the others. The mind is lost in such a labyrinth of forces, and almost refuses to proceed. But we have only entered upon the vestibule of the mysteries of the universe. Across that gulf which separates our system from the stars, unseen hands with sinews strong as steel are extended to bind all into one great whole. From each star reaches out to our sun a force, small as compared with those which hold our system together, yet of a size that will amaze us. To the nearest of these far-off suns the distance is so great that light, which travels almost 200,000 miles in a second, requires three years to traverse it! Yet gravity reaches across that gulf with a speed which, if not absolutely instantaneous, is, according to Laplace, 50,000,000 times greater than that of light. Such a distance reduces proportionably the attraction; yet our sun with its attendant planets is drawn by mutual attraction toward the nearest star, supposing them to be of the same size, with a force great enough to break a cable, each of whose strands, 236 in number, should be a solid bar of steel one mile square; or, if we change our scale, and employ such bars as those used when speaking of the interplanetary forces, bars of steel one foot square, then the attraction between the nearest tiny speck of light and our sun would be equal to the united strength of 6,500,000,000 such bars.

When we remember that each star, however remote, adds its quota of force, and that a star whose light requires 6,000 years to reach the earth is linked to our system by a band able to lift more than 14,000,000 tons, we may well believe that our system is being hurried through space in a path which is the resultant of innumerable forces.

The force which thus impels our sun reacts on other suns, and they on each other, and thus all are in movement. This is not a conclusion drawn from mere theorizing; the measurements of astronomers have established the fact that the "fixed" stars are moving with enormous velocities, not, as has often been said, about a common center, but in directions which cross each other at all angles. Millions of years hence these movements will result in the destruction of the present universe, unless He who called the stars into existence shall lay his hand upon them. If, as revelation and science both teach, not a sparrow falls to the ground without his knowledge, surely suns and worlds shall not perish without his consent. He who in the beginning created the heavens and the earth will guide them to the end.

LEGAL PROSECUTIONS OF ANIMALS.

By WILLIAM JONES, F.S.A.

AMONG the strange practices of olden times nothing can be conceived more truly absurd than the trial, by legal proceedings, of animals accused of high crimes and misdemeanors, which prevailed, more or less, from the twelfth to the seventeenth centuries, and present a curious picture of the habits of thought during those periods.

The trials in question were conducted with all the solemnity of the law. In every instance advocates were assigned to defend the animals. Domestic animals were tried in the ordinary criminal courts; wild animals of a noxious description, such as rats, locusts, caterpillars, and such like, were subjected to the ecclesiastical courts. The first excommunication fulminated against animals is recorded in the twelfth century. St. Foix, in his "Essais Historiques sur Paris," states that the Bishop of Laon pronounced in 1120 an injunction against the caterpillars and field-mice, on account of the ravages they made on the crops.

The mode of trial in the criminal courts was this: The accused animal was committed to prison; the *procureur*, or officer who exercised the functions of prosecutor at the court, after hearing witnesses and taking down their depositions, and the crime of homicide being proved, the judge condemned the animal to be strangled, and hung by the back-legs to an oak-tree, or a gibbet, according to the custom of the country. In the case of damages done to property, the inhabitants of a district suffering therefrom, experts were appointed by the court to survey and report on the subject. A lawyer was then appointed to defend the animals, and show cause why they should not be summoned before justice. They were then called three times, and, not appearing, judgment was given against them in default. The court then issued an admonition, warning them to leave the district within a certain time, at the expiration of which, if they were still contumacious, they were to be anathematized with all due solemnity. Instead, however, of feeling the effects of this terrible sentence, it is recorded that in some instances the noxious animals, contrary to "withering off the face of the earth," became more abundant and destructive. This the lawyers attributed neither to the injustice of the sentence, nor want of power of the court, but to the machinations of Satan, who, as in the case of Job, is at certain times permitted to tempt and annoy mankind.

From the thirteenth to the sixteenth century there are numerous examples of proceedings in the criminal court in the case of pigs (and sows, more particularly) who had devoured children. As one may see at present in certain localities, these animals in the middle ages ran about the streets of villages, and were, it would seem, more addicted

to a liking for human flesh than, happily—grace to the refinements of time—they are now. In the "Annuaire du Département de l'Aisne" (1812) are full details of the sentence pronounced on a hog (June 14, 1494) by the Mayor of St. Martin de Laon, for having *défacié* and strangled a child in its cradle. The sentence concludes thus: "We, in detestation and horror of this crime, and in order to make an example and satisfy justice, have declared judged, sentenced, pronounced, and appointed, that the said hog, being detained a prisoner and confined in the said abbey, shall be, by the executioner, hung and strangled on a gibbet near and adjoining the gallows in the jurisdiction of the said monks (of St. Martin de Laon), being near their copyhold of Avin. In witness of which we have sealed this present with our seal." This was done on the 14th day of June, in the year 1494, and sealed with red wax, and upon the back is written, "Sentence on a hog executed by justice, brought into the copyhold of Clermont, and strangled on a gibbet at Avin."

In 1497 a sow was condemned to be beaten to death for having eaten the chin of a child belonging to the village of Charonne. The sentence declared that the flesh of the sow should be thrown to the dogs, and that the owner of the animal and his wife should make a pilgrimage to Notre Dame de Pontoise, where, being the day of Pentecost, they should cry "Mercy!" after which they were to bring back a certificate. The execution of these animals was public and solemn; sometimes they were clothed like men. In 1386 the judge at Falaise condemned a sow to be mutilated in the leg and head, and afterward to be hung, for having torn the face and arm and then killed a child. This was a Draconian method of punishment. This sow was executed in the public square, clothed in a man's dress. The execution cost ten sous, six deniers tournois, besides a new glove for the executioner.

Bulls shared with swine the same mode of trial and punishment; horses, also, guilty of homicide had a similar ordeal. The registers of Dijon record that in 1389 one was condemned to death for having killed a man.

In the "Mémoires de la Société Royale Académique de Savoie" is a singular account of the law proceedings, instituted in 1587, against a species of beetle that made great ravages in the vineyards of St. Julien, near St. Julien de Maurienne. In 1545 these insects had made an irruption into this territory. Two lawyers had been selected, one by the inhabitants, and the other to defend the animals, and, wonderful to relate, the beetles suddenly disappeared, and the lawsuit was accordingly abandoned. It was, however, resumed forty-two years afterward, in 1587, when they reappeared and committed great ravages. The court addressed a complaint to the vicar-general of the Bishop of Maurienne, who named a judge, and also a lawyer to plead for the insects, and published an order prescribing processions, prayers, etc. After several legal discussions the inhabitants of St. Julien were in-

formed that it was necessary to provide a piece of land outside the vineyards, where the beetles could live without infringing on the vines. The land was to be of a certain extent, and to contain trees, herbs, etc., in sufficient quantity, and of good quality. The concession was made June 29, 1587, and on July 4th the counsel for the inhabitants presented a request to the court that, in default of the defendants accepting the offer, the judge would order the vineyards to be respected under certain penalties. The advocate for the animals demanded time for deliberation, and, the trial being resumed in September following, he declared that he could not accept on the part of his clients the offer that had been made to them, inasmuch as the locality in question was barren and did not produce anything. This was denied on the other side, and arbitrators were appointed to decide the question. The result is not known, as the manuscript containing the case leaves off at this point, but sufficient particulars have been given to show the extremely absurd and curious proceedings on this subject.

No district could commence a legal process of this kind unless all the arrears of tithes were paid up to the Church, and this circumstance gave rise to the well-known French legal maxim, "The first step toward getting rid of locusts is the payment of tithes." It seems that the clergy and the lawyers agreed very well together in these matters. Chasseneuz, a celebrated lawyer of the sixteenth century, writing on the subject of trying animals by law, in order to console the Beaunois for the plague of locusts (vulgarly called *huberes*), informs them that the creatures of which they complain were nothing in comparison to those that infested India. These last were no less than three feet long, and their legs were armed with teeth so powerful that saws were made of them! The best means of deliverance was to pay promptly and truly the tithes of the Church, and to cause a female (barefooted) to walk round the infected place.

The same means indicated by the lawyer for the inhabitants of St. Julien de Maurienne were employed very often, and successfully, according to some writers; thus, a famous councilor of Zurich, Félix Malléolus, or Hemmerlin (died 1457), relates that Guillaume de Saluces, who was Bishop of Lausanne from 1221 to 1229, ordered the eels of Lake Leman to confine themselves to a certain part, from which they were not to go out. He relates, also, that in the diocese of Constance and in the neighborhood of Coire were consigned, "en une région forestière et sauvage," larvæ and Spanish flies, that had been previously cited before the provincial magistrate, who, "taking into consideration their youth and diminutive size, appointed an advocate to defend them."

The summonses against offending animals were served by an officer of the criminal court, who read these citations at the places frequented by them. Though judgment was given by default on the non-appearance of the animals summoned, yet it was considered necessary that

some of them should be present when the citation was delivered; thus, in the case of the leeches tried at Lausanne, a number of them were brought into court to hear the document read, which admonished them to leave the district in three days. The citation contained a description of the animals; thus, in a process against rats in the diocese of Autun, the defendants were described as dirty animals in the form of rats, of a grayish color, living in holes. This trial is famous in the annals of French law, for it was on that occasion Chasseneuz (who wrote a work in 1588, on the excommunication of animals), the famous advocate, won his first laurels. The rats not appearing on the first citation, Chasseneuz, their counsel, with true legal subtilty, argued that the summons was of a too local and individual character; that, as all the rats in the diocese were interested, all the rats should be summoned. This plea being admitted, the curate of every parish in the diocese was instructed to summon every rat for a future day. The day arriving, but not any rats, Chasseneuz declared that as all his clients were summoned, including young and old, sick and healthy, great preparations had to be made, and an extension of time was necessary. This also being accorded, another day was appointed, and again no rats appearing, Chasseneuz objected to the legality of the summons under certain circumstances. A summons from that court, he argued, implied full protection to the parties summoned, both on their way to it and their return home; but his clients, the rats, though most anxious to appear in obedience to the court, did not dare to stir out of their holes on account of the number of evil-disposed cats kept by the plaintiffs. Let the latter, he continued, enter into bonds, under heavy pecuniary penalties, that their cats shall not molest my clients, and the summons will at once be obeyed. The court acknowledged the force of this plausible plea, but the plaintiffs refusing to be bound over for the good behavior of their cats, the period for the attendance of the rats was adjourned *sine die*, and thus Chasseneuz and his clients came off victorious.

The "Conteur Vaudois" of Lausanne publishes this strange story, which is found in the "History of the Swiss Reformation," by De Ruchat. It is not inserted as a joke, but given in sober seriousness: In 1479 the vicinity of Lausanne was infested by cockchafers; a lawsuit was commenced against them, and three processions of the inhabitants ordered. The insects were cited to appear in the bishop's court, and for counsel they had assigned to them one Perrodet, who had been dead six months! The accused and their advocate not appearing, judgment was given by default. The sentence is in Latin, and is preserved in the archives of Lausanne. The insects are excommunicated in the name of the Holy Trinity and the Blessed Virgin, and they and their descendants were ordered to quit for ever the diocese of Lausanne!

The work of De Ruchat contains another strange story. In 1364

the church of Chuttens, in the Jorat Hills, possessed a miraculous image of St. Pancrace. A pig having destroyed a child, this image was brought out, and the child was restored to life. The pig was cited to appear in the bishop's court, and, being found guilty of willful murder, was sentenced to death. De Ruchat adds that the executioner was a pork-butcher.

With an abundant share of exorcisms, charms, and enchantments for the extirpation of vermin in olden time, England does not appear to have enjoyed the notoriety of the legal proceedings against animals which we have recorded as prevalent in foreign countries. There is, however, a curious case of the trial of a dog in 1771, near Chichester, which gave rise to a facetious parody, "A Report of the Case of Farmer Carter's Dog, Porter," by Mr. Long, a lawyer, who died in 1813. Home, in his "Every-day Book" (vol. ii.), gives an account of this mock trial, somewhat abridged from the original pamphlet in his possession, but without other alteration, together with a portrait of the dog Porter in the dock. The names of the parties engaged in the real trial are given, with those of the nicknames in the parody. The former are Butler, Aldridge, Challen, and Bridger, understood by the names of J. Bottle, A. Noodle, Mat o' th' Mill, and O. Ponser.

In Lord Fountainhall's "Chronological Notes of Scottish Affairs," a curious affair is mentioned in connection with the boys of Heriot's Hospital in 1681–'82, the year in which the Earl of Argyll was tried and convicted of high treason for refusing the test-oath without certain qualifications. The hospital boys made a mockery of the reasoning of the Crown lawyers on this subject. They resolved among themselves that the house-dog belonging to the establishment held a public office and ought to take the test. The paper being presented to the mastiff, it refused to swallow the same unless it was rubbed over with butter. Being a second time tendered, *buttered*, the dog swallowed it, and was next accused and condemned for having taken the test, with a qualification, as in the case of Argyll !

Charms and exorcisms for the dispersion or destruction of noxious animals prevailed from a remote period, and some of the superstitions, in a modified sense, still exist in our own country, and especially abroad. In the middle ages, history makes frequent mention of the calamities caused by plagues of insects. These were the more destructive, as agricultural science, almost in its infancy at that period, offered few remedies for preventing or mitigating the ravages. Recourse was consequently had to the assistance of the clergy, who listened to the complaint, interposed with prayers, and anathematized those enemies of mankind as the work of Satan. Thus St. Mammet, Bishop of Vienne, exorcised certain devils who had taken the figures of wolves and pigs, and had devoured children. Gregory of Tours (573–595) alludes in his "History" to talismans against mice, serpents, and conflagrations.

The suits against animals not unfrequently led to more serious

trials of human beings on charges of sorcery. Simple country people finding the regular process very tedious and expensive, purchased charms and exorcisms from empirical, unlicensed exorcists at a much cheaper rate, but, if any of the parties concerned in this contraband traffic were discovered, death by stake and fagot was their inevitable fate. Still there was one animal, the serpent, which, as it had been cursed at the earliest period of the world's history, might be exorcised and charmed (so that it could not leave the spot where it was first seen) by any one, lay or cleric, without the slightest imputation of sorcery. The formula ran thus: -"By him who created thee, I adjure thee that thou remain in the spot where thou art, whether it be thy will to do so, or otherwise; and I curse thee with the curse with which the Lord hath cursed thee."

In the seventeenth century the cases of law proceedings against animals became rare, for the Church at this period had almost renounced these absurd practices. Thus, for example, in the "Ritual of Evreux," of 1606, Cardinal Duperron declares that no one should exorcise animals nor use prayers and formulas without his express permission. But the delusion was too widespread to be restrained. In Spain and Italy exorcists abounded, as in France. Azpilcenta, of Navarre, a distinguished Spanish canonist, asserts that rats when exorcised were ordered to depart for foreign countries, and would march in large bodies to the seacoast, and thence set off swimming in search of desert islands. Father Manoel Bernardes, in his "Nova Floresta" (published at Lisbon, 1706–1708), gives a long account of the trial of ants in Brazil in the commencement of the eighteenth century. The particulars are too long to be given in detail, but it appears that the monks of St. Anthony complained of the sacrilegious behavior of certain ants that ate their grain, and otherwise misconducted themselves, devouring the cloths of the altar, and bringing into the church pieces of shrouds from the graves beneath the church. The sentence was that the friars should provide a suitable place for the ants to remove to, which seems to have satisfied the defendants—*it nigrum campis agmen;* millions of ants immediately came out, forming themselves in long, dense columns, and proceeded direct to the field assigned to them.

In America birds of prey and insects were excommunicated. The Baron de la Houtan, who toward the end of the seventeenth century passed several years in Canada, relates that "the number of turtle-doves was so great in that country that the bishop was obliged to excommunicate them several times on account of the damages done by them." A similar infliction was pronounced in Peru against the *termites*, a species of white ant, that had got into a library and devoured a great number of books. In the "Voyages of La Perouse," it is stated that millions of cockroaches got into the bread-room, and recourse was had to exorcisms more than once.

The ceremonies attending the exorcism of animals were sometimes

accompaned by a loud clashing of musical instruments: thus, it is mentioned in the "Life of St. Patrick," that he was unable with the most formidable interdicts to drive away a cloud of bats that had been taken for demons; but what his formulas could not effect was done by a deafening sound of cymbals, which drove them away, as may well be imagined, in great affright. The greatest of the numerous miracles ascribed to St. Patrick was that of driving the venomous reptiles out of Ireland. Colgan seriously relates that the saint accomplished this feat by beating a drum, which he struck with such fervor that he knocked a hole in it, thereby endangering the success of the miracle, but an angel appearing, mended the drum, and the patched instrument was long exhibited as a holy relic. The Rev. Alban Butler, however, in his "Life of St. Patrick," states as a popular tradition of the Irish, that the miracle was given by his staff, called the "Staff of Jesus," which was kept in great veneration at Dublin.

Ribadeneira, the Jesuit author of "Lives of the Saints," states that no venomous beasts after the miracle could live or breathe in Ireland, "and that even the very wood (of the country) has virtue against poison, so that it is reported of King's College, Cambridge, that being built of Irish wood no spider doth ever come near it."—*Abridged from Land and Water.*

PSYCHOGENESIS IN THE HUMAN INFANT.*

By Professor W. PREYER, of Jena.

WHOEVER would watch the growth of the human mind must first make the soul of the child the object of a methodical investigation. The new-born child in its pitiful helplessness is already an object of extraordinary interest for the psychologist; yet it seems incomprehensible that the progressive unfolding of the senses of the infant—of his will, his reason, his passions, his virtues—has not engaged the attention of any but his relatives. For thousands of years children have been born and lovingly taken care of by their mothers, and for as long a time the learned have contended respecting the growth of their minds without studying the children themselves. The volumes that have been written on the subject without this study are of small use, because they lack the basis of fact. Schoolmasters and tutors can give but little help in the investigation, for the development of the faculties begins long before they are called in to assist it.

The study of the earliest mental growth is useful in its bearing upon the future training of the child. Only certain faculties are innate in every man. A true method of instruction should proceed from the

* Translated from the German by W. H. Larrabee.

given inherited faculties; should take account of their diversities; should not measure all children with the same measure; and should not train them after the same model. It would be desirable in respect to this point if a number of men well versed in physiology should, independently of each other, carefully observe as many infants as possible, and compare results; or if the fathers of children, friends to each other, should mutually exchange observations upon their own children. It would be well for individuals to keep a day-book of the acts of their children from their birth upward. I can say from my own experience that hardly a day passes in the first two years in which something does not occur worthy of notice in its bearing upon mental development. The study must begin with the observation of the sensations and movements of the child. There can be no mental activity without sensation to excite it by giving impressions, and affording a basis for remembrances and comparisons. The sensations are preceded by the movements which begin even before the child is born. The reciprocal action of sensation and movement leads us a step further, to the beginning of the development of the will. As soon as the will becomes effective, the intellect reveals itself, and at last the point is reached when inclination becomes a controlling influence; the feelings assume a real form, and the child begins to communicate its own purposes through speech. The first cry of the new-born child has been regarded by some as an expression of the will, and even as an appeal for relief from pain. This can not be, for a being born without understanding, in the first moment of consciousness, can not be capable of entertaining such purposes as this expression would imply. A more probable theory is that it is the result of a reflex action, like the sounds with which animals respond to a pleasing excitation, as the rubbing of the back, or like the laughter which is provoked by tickling. Frequently the child sneezes instead of crying; and this is a purely reflex action, following an irritation of the nerves of the nose.

The first motions of the limbs of the child give to the unprejudiced observer an impression of aimlessness. The changes in the expression of the face seem to result from what are more like voluntary muscular movements; but when we remember how helpless are the motions of the infant in other respects—that it will be months before it can hold up its head or take hold of any thing, or do any other simple act which seems natural to grown persons—this supposition seems no longer probable. Of what nature, then, are these singular muscular contractions which are never observed again in the whole later life, and the parallels of which are only seen in animals suddenly awakened from their winter slumbers, or occasionally from ordinary sleep? No external cause of disturbance is present to irritate the nerves of motion and the contractile fibers, and so provoke reflex movements. The sleeping infant stirs as the waking one does, only less often and more sluggishly. We can not ascribe the movements at this early period of life to attempts

at imitation ; the imitative faculty does not begin to be developed till the second half-year. We must look within the child for their cause. An inner cause must be either acquired or inherited. The idea of an acquired cause presupposes varied experiences and observations, of which the child has had none. The inherited causes, then, are the only ones we can consider. It is not enough to say on this point that the child moves as it does because its ancestors did so when they were young. That would only set the problem a step further back. We should rather say that the peculiar movements take place because the central nervous motor organs, when they are fully developed, discharge irregularly the surplus store of motive energy which has been inherited. They have been called instinctive, but instinct comprehends a kind of inherited recollection, and has some definite end, while the motions are aimless. They are impulsive—the direct effect of the nervous energy of the spinal marrow before it has become subject to the restraint of the brain. As the brain is developed, and the intellect manifests itself, the excessive movements are limited, and in persons who have received the most perfect training they are hardly observed at all. They cease when the man has learned to exert the full power of his will over them.

The first manifestation of the will in the child appears when it begins to hold up its head. A chicken can not hold its head up during the first hour after it is hatched ; but it can do that, and even pick up a grain of corn, before it can walk or stand firmly. It then begins to run, and learns to do in a day what it takes the human infant a year to accomplish. My attempts to hold a child up straight were not successful for fourteen weeks. Evident voluntary effort began at that time, and after four months the child was able to keep its head well balanced. The lack of power to hold the head up before was not due to want of muscular strength, for the reflex actions, such as that of turning the head, requiring as much power of muscle, were performed firmly enough. Next, after the head, the upper part of the body was balanced. The power to sit up was acquired in about the tenth month, all at once, after the child had been kept up by artificial supports for several weeks. So ability to stand was gained suddenly at the end of the first year, after numerous unsuccessful efforts to stand by the aid of chairs, tables, and the walls of the room. The next acquisition, that of walking, likewise seems to come of itself. Its beginning is obscure, for there appears no occasion in the act of standing for the alternate bendings and stretchings of the legs which enter into it. Similar movements may take place, it is true, when the child is lying down, in its bath or in its cradle, but the regular alternation of them in a standing position is quite different, and is probably, like the act of sucking, derived by inheritance.

It may often be months before the effort to walk is successful, but, if the child is allowed to creep without being interfered with, it will

in time begin to walk without instruction. The efforts of walking, standing, and sitting can not be ascribed to any knowledge of the advantage of those actions. They rather arise from the growing power of the will in connection with the muscles and motor nerves, bringing those organs into the modes of action which will prove in later life to be of most advantage to the body, just as has regularly happened to our ancestors. So deeply have the traces of these motive impulses been impressed, so often has the will gone on these nerve-paths and no others, that they are followed at once as soon as the motive impulses of the new-born man are developed. In other words, the efforts are instinctive. The child walks when the inclination to change place is so strong that creeping does not satisfy it, or when it wills to walk, as it sits up or stands when its will to do so is strong enough to command the requisite muscular action. A child observed by me, which could already stand well, all at once, at the end of the fifth quarter-year, for the first time ran around a table, unsteadily, like a drunken man, but without falling. From that day on it went erect, at first hurriedly, then trotting with extended arms, as if to keep from falling, then slower and more firmly. In the course of the next month it went over a door-sill an inch high between two rooms, but holding on to something, and frequently lifting its foot up too high or stamping it down, like one afflicted with a spinal disease. Its will had not yet full control of its muscles, and it could not measure the force of its efforts.

The movements of grasping afford interesting objects of observation. Their development has to be watched with care, for it sometimes takes place at a bound from a lower to a higher degree; at others, proceeds very slowly. A pencil put in the little hand was clasped by the fingers during the first quarter-year; the thumb participated in the action, but not independently—rather as if it were one of the fingers—and the infant did not seem to be aware that it had anything in its hand, holding the object mechanically, as it were. If, at this time, one puts his finger into the child's hand, it will seem to grasp it and hold it, the more so as it keeps a tight hold when the finger is moved back and forth. The action is, however, wholly reflex; there is no intended grasping. The first real effort to take hold of an object was observed in the seventeenth week, when the infant reached after a little India-rubber ball which was near it. When the ball was put into its hand it held it tight for a long time, brought it to its mouth, held it close before its eyes, and looked at it with a peculiar, novel, intelligent expression. On the next day it made many awkward but earnest attempts to take hold of objects of all kinds which were presented before it, fixing its eyes fast upon them, and reaching after things which were too far for it to seize. On the following day, it seemed to give it pleasure to take hold again and again of everything which was within its reach. Wonder was also mingled with its pleasure, and

another step was noticed in the development of the infant mind. Toward the end of the fourth month the child raised its arms toward its parents with an indescribable expression of longing. The transition, from grasping after indifferent things so as to take them to itself to reaching after its parents to get nearer to them, was sudden. On the other hand, its own arms and feet appeared to the child for months as something strange, not belonging to it, and it would stare at them and examine them as it did with other objects which engaged its attention. It would take hold of its feet and bring them to its lips; it would bite its arm even in the fifth quarter-year, so as to cause it to cry out in pain; it would offer biscuit to its foot to eat, as it did to its wooden horses. There appeared, as yet, no sign of self-consciousness. The unintermitted grasping of objects leads gradually to the comprehension and knowledge of separate existences and the seclusion of self.

Now that the object which has been seen and wished for is touched, a new sensation excites the attention of the child. That which was light or dark, colored or bright, appears to be also smooth or rough, heavy or light, hard or soft, warm or cold, and presents combinations in the same thing appealing to two or three senses. The same apple is red and green, smooth and heavy, cold and hard, and also smells and tastes agreeably. The junction of the sensations of sight, touch, smell, and taste at the same point excites surprise, induces reflection, and arouses the insatiable propensity of the mind to inquire into the causes of its affections. The infant examines the object it is holding, feels of it, and rubs it every way, moves it back and forth, takes it to pieces, and tries to put it together again. With these exercises the will becomes more fully developed. As soon as it is possible to learn the nature of external objects which have affected the senses by examining them, the act of grasping becomes voluntary. Will is developed from the previous desire. The remembrance of the satisfaction which the success of an effort to grasp something has given awakens, at the sight of a new object, the idea of getting hold of it, and with it the impulse to exert the necessary movement. This impulse is called the will. It is still weak in the child, for he lacks self-control, but the obstinacy of early youth shows often enough the force that lies in the unrestrained will.

The sensibility of the skin of a new-born child is very low. We may cause it to cry in the first hour by striking it or by touching it too roughly, but its cries are only reflex actions, not expressions of pain; on the other hand, we may stick needles into its nose, lips, or hands, without its giving any sign of discomfort, even if so deep a wound is made as to draw blood. I have never tried any experiments of this kind, but I have found that the eyes of new-born children close, when they are touched, more slowly than at a later period and are only imperfectly shut at that, and that they do not close when they are wet in the bath. An increase of sensibility may be perceived in the course

of one or two days, especially in relation to temperature. The earliest sensations of temperature are, however, of less immediate psychogenetic significance than those of touch. The hands of the child are the feelers of his soul. Through the excitation of the tactual corpuscles, at the points of the fingers and in the lips, the infant receives the first knowledge of things without him; and through the difference in the sensations arising from the touch of his own skin and that of foreign objects is the foundation laid for self-consciousness on one side and for making experiments on the other. His fingers are, in fact, the instruments with which he endeavors to explore everything that comes within his reach.

Professor Kussmaul has described some important experiments on the sense of taste in infants, in which he found that all new-born children could distinguish strong tastes, and that a very different reaction took place when the tongue was wet with a solution of sugar, from that which followed the application of quinine, vinegar, or salt. Signs of distaste were excited by the three latter substances, and of satisfaction by the sugar, which showed beyond doubt that the power to discriminate tastes begins at birth. The opinion that infants will take alike whatever is offered them holds good if at all, only of substances whose taste is weak. If the child seems displeased at the taste of a strong solution of sugar, as sometimes happens, that is only the effect of the surprise which all new intense sensations occasion. After the first trial, it will want more sugar, and show its satisfaction at getting it. The same is the case with the young of animals, which readily distinguish tastes and seem astonished at new ones; and the newly hatched chicken will at once select the food, where it is given a choice, which is most agreeable to it. Taste is, then, the first sense which affords clear perceptions, and is the first which gives occasion for the exercise of the faculties of memory and judgment.

The sensations of smell can hardly be separated from those of taste. Infants appear able to distinguish odors very early, but to what extent has not been ascertained. They are able to tell one kind of food from another by this means, and have been known to decline the acquaintance of a new nurse whose presence was disagreeable to them. It is known that animals that are born blind are guided to their food —the mother's milk—by this sense. Some odors, as that of tobacco-smoke, have been found to be disagreeable to young animals; others, as that of camphor, pleasant.

All infants are deaf at birth, because the outer ear is as yet closed, and there is no air in the middle ear. A response to a strong sound is observed, at the earliest, in six hours, often not for a day, sometimes not for two or three days. The awakening of the sense may be recognized by means of the drawing up of the arms and the whole body, and the rapid blinking which a loud noise provokes; and it is a sign of deafness if the child, after its ears have had time to come into a suit-

able condition for hearing, fails to respond thus to a strong sound. No other organ of sense contributes so much to the early spiritual development of the child as that of hearing after it has become fully developed. The superiority of the ear over the eye in regard to this point is shown by the intellectual backwardness of persons who are born deaf as compared with those who are born blind. At the beginning of life, as a rule, the voices of the mother and the nearest relatives afford the first impressions of sound. Very soon these voices are distinguished, and different tones and noises are differently responded to. It is particularly interesting to compare the soothing operation of singing of the cradle melodies with the extraordinary vivacity exhibited on the hearing of dance-music, in the second month. Certain sounds, as those of the consonants *sh*, *st*, and of the male voice, are effective at a very early period in quieting the crying of a child, while other strong and strange ones, like the whistle of an engine, will cause it to cry. Observations on these points, which are easily multiplied, show that, in spite of its original deafness, the child learns very soon to discriminate between the impressions of sound.

The faculty of seeing has a similar growth. Light seems at first unpleasant, and only faint lights are borne; the baby shuts its eyes tight when a candle is brought near them. Brightness and darkness, if they are marked, can be distinguished, but with this the office of the eyes in the earliest days is exhausted. The motions of the eyes are wholly unregulated. One will look to the right, the other to the left; one may be open, the other shut; one will be still while the other moves. Among the numerous combinations of movements both eyes will occasionally move together, but no real symmetry in the muscular contractions can be predicated for the first six days. The first perceptions are evidently only those of the different degrees of strength of light. These attract attention, and some children are said to have turned their heads to the window after the first day. I have noticed it on the sixth day. On about the ninth day most infants begin to stare, into the void, or if a bright object, as a candle, is brought before them, as if they were looking at it; but it is easily found out by trial that there is no real seeing, for it is only when the light is brought directly within its line of vision that the eye is directed toward it. Not for three weeks will the eye which is turned toward a light follow it when it is slowly moved, and then only with a partial motion of the head. But little intelligence is involved in this, for the movements of the eyes and of the head are often in opposite directions. Nevertheless, the face of a month-old child gains an appearance of intelligence when it looks with both eyes upon a slowly moving object and follows its motions; but the stupid expression returns, and does not finally disappear till the second quarter-year. The face grows more human and spirited as the power is gained of regarding objects with a steady, independent look. The faculty of accommodation, or the power of

rapidly adapting the eye to the perception of objects at different distances, is then in the process of development, and the unsymmetrical movements of the eyes gradually cease.

The power to distinguish colors follows. One child prefers yellow, another red; all dislike black and dark colors as well as dazzling bright ones. It is hard to decide when the finer degrees of color and their grades of brightness begin to be recognized, for the time differs with the individuals. I do not know of any child that could point out red, green, yellow, blue, correctly on demand before the beginning of the third year.

The recognition of forms proceeds very slowly. Experiments on blind persons, who have had their sight restored by operations, after they had learned to see, show that they could not distinguish curved figures from angular ones by sight alone, nor at all until they had felt of them. The same is doubtless the case with every little child. Numerous observations show how defective is the estimation of distances in early years. The well-known reaching out for the moon is a case in point. Even long use does not give accuracy in the exercise of this power. The same is the case with the perception of magnitudes. A child in its third year will try to put its larger playthings into the boxes designed for little ones, to put pieces of bread into its mouth that are too large for it, and to take hold of large things with its tiny hands. The first sensations of changes in the field of vision, such as are given when a bright object is taken from it, as by the extinction of a lamp, and when a new object is substituted for it, as when the lamp is lighted again, always make a deep impression on the young child. In the first month no notice is taken of the swiftest approach of the hand to the face, and the act of blinking when a threatening movement is made toward the eye is not acquired till the third month. This fact enables us to distinguish between inherited and acquired incidents of sight. The contraction of the pupil in the light and its expansion in the gloom are inherited, and common to all new-born children; the blinking is acquired: it is a precaution against danger, of which the child in its first months knows nothing. By frequent repetitions it becomes habitual, and at last reflexive, like other defensive contractions of the muscles. By the frequent repetition of observations and experiments of the kind described above, it is possible to follow the gradual development of the senses in individuals. But much material must yet be collected before we can clearly set forth the sensual basis of the spiritual growth of the child. The sensations are the material out of which every man makes his world. The emotions of the child, his inclinations and disinclinations, the development of his sense of obligation, the beginning of the formation of his character, the opening of his talents, all depend primarily on the unfolding of his senses. We have so far, on this subject, nothing but an array of facts, with little connection between them.

The study of the growth of the faculty of speech is also of the highest importance in its bearing upon our knowledge of the condition of the child's mind, and of his intellectual operations. I have been in the habit of setting down daily on paper every expression, every sound that could be represented in writing, uttered by a child during the first two years, and am about to publish, on the basis of the facts thus gathered, a special work on the history of the growth of the power of speech. I can give here only a few notes of general interest.

It is extremely hard to exclude the influence of imitation from the child; and, when it is not excluded, to separate what is acquired by it from what is inherited. No one will believe that a child was ever born able to speak, or that he could learn to speak without exercising the power of imitation. Yet it would be wrong to conclude that the faculty of speech is acquired, or is absolutely not inherited. Whatever properties of organisms are constantly repeated periodically are called hereditary; whatever endures through many generations is called inherited. Speech thus endures. It can not be said to be born with the child any more than the teeth and beard are born with him, but the foundation of it, the predisposition to it, is born with the child, the same as are the foundations of those organs. And when a person is prevented from speaking by some defect of his organs of speech, he proves that the faculty still exists within him by the readiness with which he will take up a substitute for speech—writing, or the sign-language. The psychologist can hardly experience a greater intellectual enjoyment than that which is given by observing the development of speech from the first reflexive cry through the thousand and one days of the beginning of human life; at first unintelligible, gradually flowing slowly and interruptedly from unrevealed sources, then gushing lively and irregularly, afterward getting slowly relieved of the non-essentials and becoming more orderly and plain, clearer, and flowing; finally, proceeding in a clear stream of connected language, which testifies to the rule of reason over the natural inclination, the victory of the will, and the formation of thought.

At first only the vowel-sounds are uttered. Even in the first five weeks the tones are so diversified that the condition of the child can be learned from them alone. The periodically broken cry, with knit eyes, denoting hunger; the continuous whine for cold; the high, penetrating tone expressing pain; the laugh over a bright button; the crow of pleasure; the peculiar expression, with motion of the arms, of the wish for a change of position—are easily distinguished utterances, partly reflexive, partly expressive. The prattlings of the infant during the first six months can not be represented on paper, and appear to be significant only of the general muscular movements in which the organs of speech participate, combined with the flowing in and out of the air. I heard the first consonant, *m*, in the seventh week; in the seventh month only *m*, *b*, *d*, *n*, *r*; rarely *g* and *h*, very rarely *k*, could

be distinguished in the babblings. Gradually the voice became more steadily modulated. When the child wanted some new thing, besides stretching out its arms and looking at it, it signified its desire by the same sound it had been accustomed to utter when it wanted to be nursed. At the same time the syllables *pa, at, ta, ba, da, ma, na,* common to children of all nations, were uttered plainly and frequently. They had no meaning, and were only the consequences of the involuntary exercises of the vocal apparatus.

Very imperfect imitations of sounds were noticed toward the end of the first six months. The power of distinguishing words when spoken began to appear at about the same time. The baby turned its head when it was called, and it was taught to do such little acts as give its hand when asked to. Still, the store of words it knew was not larger or more comprehensive than that of a well-trained hunting-dog. The enormous intellectual interval between the child and the trained animal was manifested less by its connection of definite objects with certain changes of sound than by its feeble attempts to repeat the syllable or the word when the impression recurred to which they corresponded.

Great progress is made in the imitation of sounds after the third half-year. Numerous objects are correctly pointed out in answer to questions, and many words are spoken with a broken articulation, but in a correct sense. The child's advancement in the power of forming notions becomes wonderfully rapid, and it learns to connect its ideas, to compare and reflect before it has acquired the use of any considerable number of words, and while it still expresses its thoughts by gestures more than by words.

The powers of articulation become well developed at the beginning of the fourth half-year, although the child may still not be able to pronounce all the sounds of his language; but an intelligent child is able to understand many more words than he can repeat, and will also repeat, in a parrot-like way, many words that he does not understand, if they please him or he finds that his speaking them pleases others.

The organs of articulation have a wonderful flexibility, putting it into the power of the child to learn to pronounce the sounds of any language which may be taught him with an ease and accuracy which can never be gained later in life. The child's own language is, however, crude and elementary, consisting in the main of inarticulate sounds, looks, gestures, parts of words that are mangled beyond all recognition, and onomatopoetic expressions. The way he learns to speak is incomprehensible to the keenest observer. He cries, laughs, babbles, smacks, crows, squeals, and understands what is said to him long before he speaks; and after he has touched, looked, listened, and tasted innumerable times, after he has amused himself and got tired with a thousand efforts to imitate, after he has been at first unable to repeat, and often would not repeat words, then he speaks spontaneously. At first he speaks in such a way as to make a single word answer for

several whole phrases. Shortly, two, three words are spoken in connection; then the child is able, in broken phrases, to give an imperfect account of something that has happened. It is not a very long step from these beginnings to the construction of real sentences. The use of the pronouns, verbs, and articles, is attended with difficulties for some months, but the way is broken. The sentence gradually assumes a correct shape, and the child at last gives clear evidence of his intellectual power, more through his shrewd questions than his answers.

If we compare the defects of childish speech with the lapses of grown persons after their faculties have been disturbed by sickness, we shall discover parallels of uncommon interest and astonishing completeness. All the faults of speech caused by sickness have their miniature counterpart in the child. From illness, the matured man is no longer in a condition; in childhood, the unmatured man is not yet in a condition, to speak correctly. In the former case, existing powers are disturbed; in the latter the powers of articulation and phrase-making have not been perfected. One condition helps us to understand the other. The parallel can not, however, be pursued here, for the material for illustrating it is rich and will not admit of abridgment. My present purpose has simply been to sketch the fundamental conditions of the earliest development of the infant mind independently of the theories of the day, and to set forth the extraordinary significance of the study.

CLIMBING PLANTS.

By FRANCIS DARWIN, F. L. S.

I THINK most people have a general idea of what a climbing plant is. Even in the smoky air of London two representatives of the class flourish. A certain house in Portman Square shows how well the Virginian creeper will grow; and the ivy may be seen making a window-screen for some London dining-rooms.

Many other climbing plants will suggest themselves—the vine, the honeysuckle, the hop, the bryony—as forming more or less striking elements in the vegetation.

If we inquire what qualities are common to these otherwise different plants, we find that they all have weak and straggling stems, and that, instead of being forced, like many weakly-built plants, to trail on the ground, they are all enabled to raise themselves high above it, by attaching themselves in some way to neighboring objects. This may be effected in different ways: by clinging to a flat surface, like the ivy; or twining round a stick, like the hop; or making use of tendrils, like the vine.

These various contrivances have been studied by more than one German naturalist, as well as by my father, in whose book on the "Habits of Climbing Plants" very full details upon this subject will be found.

Climbing plants are, first of all, divided roughly into those which twine and those which do not twine; twiners are represented by the hop and the honeysuckle, and all those plants which climb up a stick by winding spirally round it. Those which are not twiners—that is, which do not wind spirally round a stick—are such as support themselves by seizing hold of any neighboring object with various kinds of grasping organs; these may be simple hooks, or adhering roots, or they may be elaborate and sensitive tendrils, which seize hold of a stick with a rapidity more like the action of an animal than of a plant. We shall come back to this second class of climbing plants, and shall then consider their various kinds of seizing organs. I merely wish now to insist on the importance of distinguishing between these two methods of climbing, in one of which the plant ascends a support by traveling spirally round it; in the other, fixes on to the support by seizing it at one place, and continuing to seize it higher and higher up as its stem increases in length.

I have heard the curator of a foreign botanic garden bitterly complain of his gardeners that they never could learn the difference between these two classes of climbing plants, and that they would only give a few bare sticks to some tendril-bearing plant, expecting it to twine up them like a hop, while the plant really wanted a twiggy branch, up which it might creep, seizing a twig with each of its delicate tendrils, as it climbed higher and higher. These two kinds of climbers—twiners and non-twiners—may be seen growing up their appropriate supports in any kitchen-garden where the scarlet-runners twine spirally up tall sticks, while the peas clamber up the bushy branches stuck in rows in the ground.

A hop-plant will supply a good example of the mode of growth of true twining plants. Let us imagine that we have a young hop-plant growing in a pot; we will suppose that it has no stick to twine up, and that its pot stands in some open place where there are no other plants to interfere with it. A long, thin shoot will grow out, and, not being strong enough to support itself in the upright position, will bend over to one side. So far we have not discovered anything remarkable about our hop; it has sent out a straggling shoot, which has behaved as might be expected, by falling over to one side. But now, if we watch the hop-plant closely, a very remarkable thing will be seen to take place. Supposing that we have noticed the shoot, when it began to bend over, pointed toward the window—say a north window—and that, when we next look at it after some hours, it points into the room, that is to say, south, and again, north after another interval, we shall have discovered the curious fact that the hop-plant has a certain power

of movement by which its shoot may sometimes point in one direction, sometimes in another. But this is only half the phenomenon, and, if we examine closely, we shall find that the movement is *constant and regular*, the stem first pointing north, then east, then south, then west, in regular succession, so that its tip is constantly traveling round and round like the hand of a watch, making on an average, in warm August weather, one revolution in two hours. Here, then, is a most curious power possessed by the shoots of twining plants, which is worth inquiring further into, both as regards the way in which the movement is produced, and as to how it can be of any service to the plant. Questions are often asked in gardening periodicals as to how hops or other climbing plants always manage to grow precisely in the direction in which they will find a support. This fact has surprised many observers, who have supposed that climbing plants have some occult sense by which they discover the whereabouts of the stick up which they subsequently climb. But there is in reality no kind of mystery in the matter: the growing shoot simply goes swinging round till it meets with a stick, and then it climbs up it. Now, a revolving shoot may be more than two feet long, so that it might be detained in its swinging-round movements by a stick fixed into the ground at a distance of nearly two feet. There would then be a straight bit of stem leading from the roots of the plant, in a straight line to the stick up which it twines, so that an observer who knew nothing of the swinging-round movement might be pardoned for supposing that the plant had in some way perceived the stick and grown straight at it. This same power of swinging round slowly comes into play in the very act of climbing up a stick.

Suppose I take a rope and swing it round my head: that may be taken to represent the revolving of the young hop-shoot. If, now, I allow it to strike against a rod, the end of the rope which projects beyond the rod curls freely round it in a spiral. And this may be taken as a rough representation of what a climbing plant does when it meets a stick placed in its way. That is to say, the part of the shoot which projects beyond the stick continues to curl inward till it comes against the stick; and, as growth goes on, the piece of stem which is projecting is, of course, all the while getting longer and longer; and, as it is continually trying to keep up the swinging-round movement, it manages to curl round the stick. But there is a difference between the rope and the plant in this—that the rope curls round the stick at the same level as that at which it is swung, so that, if it moves round in an horizontal plane at a uniform height above ground, it will curl round the stick at that level, and thus will not climb *up* the stick it strikes against. But the climbing plant, although it may swing round when searching for a stick, at a fairly uniform level, yet, when it curls round a stick, does not retain a uniform distance from the ground, but by winding round like a corkscrew it gets higher and higher at each turn.

One may find a further illustration of the action of twining in the swinging-rope model. It is a peculiarity of twining plants that they can only ascend moderately thin supports. A scarlet-runner can climb up a bit of string, or a thin stick, an inch or two in diameter, but when it comes to anything thicker than this it fails to do so. Just as, when the swinging-rope strikes against a large trunk of a tree, it would be unable to take a turn round it, and would fall to the ground instead of gripping it with a single turn, as it does a thin stick. The difficulty which a climbing plant has in ascending a thick stick will be better understood by going back to the original swinging-round movement which the plant makes in search of a stick, and considering how the movement is produced.

As plants have no muscles, all their movements are produced by unequal growth; that is, by one half of an organ growing in length quicker than the opposite half. Now, the difference between the growth of a twining plant which bends over to one side and an ordinary plant which grows straight up in the air lies in this, that in the upright shoot the growth is nearly equal on all sides at once, whereas the twining plant is always growing much quicker on one side than the other.

It may be shown by means of a simple model how unequal growth can be converted into revolving movement. The stem of a young hop is represented by a flexible rod, of which the lower end is fixed, the upper one being free to move. At first the rod is supposed to be growing vertically upward, but when it begins to twine one side begins to grow quicker than any of the others: suppose the right side to do so, the result will be that the rod will bend over toward the left side. Now, let the region of quickest growth change, and let the left side begin to grow quicker than all the others, then the rod will be forced to bend back over to the other side. Thus, by an alteration of growth, the rod will bend backward and forward from right to left. But now imagine that the growth of the rod on the sides nearest to and farthest from us enters into the combination, and that, after the right side has been growing quickest for a time, the far side takes it up, then the rod will not bend straight back toward the right, as it did before, but will bend to the near side. Now the old movement, caused by the left side growing quickest, will come in again, to be followed by the near side growing quickest. Thus by a regular succession of growth on all the sides, one after another, the swinging-round movement is produced, and by a continuation of this action, as I have explained, the twining movement is produced.

I have spoken as if the question of how plants twine were a completely solved problem, and in a certain sense it is so. I think that the explanation which I have given will remain as the fundamental statement of the case. But there is still much to be made out. We do not in the least know why every single hop-plant in a field twines like a

left-handed screw, while every single plant in a row of beans twines the other way; nor why in some rare instances a species is divided, like the human race, into right- and left-handed individuals, some twining like a left-handed, others like a right-handed screw. Or, again, why some very few plants will twine half-way up a stick in one direction, and then reverse the spiral and wind the other way. Nor, though we know that in all these plants the twining is caused by the change in the region of quickest growth, have we any idea what causes this change of growth. There is still much to work at, and it is to be hoped that there are still plenty of workers to solve the problems. It is by looking to exceptions that the key to a problem is often found. It is the exceptions to general rules that often lead us to understand the meaning and origin of the rules themselves; and it is to such exceptions that any one who wants to work at climbing plants should turn. Now, it is a general rule that a climbing plant twines in the same way that it revolves. It seems an obvious thing that in the case of the rope model, if we swing the rope round our head in the direction of the hands of a watch, it must twine round the stick against which it strikes in the same direction. But in plants it is not always so. In the large majority of cases it is so, for, if this were not the case, the illustration of the rope would not have been applicable; but it is not universally the rule. Every individual of the plant *Hibbertia* always twines round its stick in the same direction, but, when it is performing the swinging movement in search of a support, it is found that some plants travel round with the sun, others in the opposite direction. This fact forms an exception of a striking kind—and such exceptions are worthy of close study.

There are other facts of a different nature, which seem to show how difficult the problem is, and how delicately balanced is that part of the organization of the plant which is connected with the power of climbing. For instance, if we cut a branch of most shrubs, and put it in water, it goes on growing, apparently as healthily as ever. Indeed, the practice of making cuttings—where a cut-off branch or shoot develops roots and turns into a new plant—shows us that no serious injury is thus caused. But the twining organization is sensitive to such treatment. A cut branch of hop placed in water was observed to make its revolutions in about twenty hours, whereas in its natural condition—growing on the plant—it makes a complete turn in two or three hours. Again, if a plant growing in a pot is moved from one greenhouse to another, the slight shaking thus caused is sufficient to stop the revolving movement for a time—another proof of the delicacy of the internal machinery of the plant.

Some of the problems, as, for instance, why twining plants can not as a rule climb thick stems, may be looked at from the natural-history point of view. Most of our climbing plants die down in the winter, so that, if they were able to climb round big tree-trunks, they would

waste all the precious summer weather in climbing a few feet, whereas the same amount of longitudinal growth devoted to twining up a thin stick would have raised them up to the light after which they are striving. And as a plant exercises no choice, but merely swings round till it hits against an object, up which it will then try to twine, it seems as if the inability to climb thick stems might be a positive advantage to a plant, by forcing it to twine up such objects as would best repay the trouble.

In the classification of climbing plants, proposed by my father in his book, he makes a subdivision of "hook-climbers." These may be taken as the simplest representatives of that class of climbers which are not twining plants. The common bramble climbs or scrambles up through thick underwood, being assisted by the recurved spines which allow the rapidly growing shoot to creep upward as it lengthens, but prevent it from slipping backward again; the common goose-grass (*Galium*) also climbs in this way, sticking like a burr to the side of a hedge-row up which it climbs. Most country boys will remember having taken advantage of this burr-like quality of *Galium* in making sham birds'-nests, the prickly stems adhering together in the desired form. Such plants as the bramble or *Galium* exhibit none* of the swinging-round movement which I have described in twiners: they simply grow straight on, trusting to their hooks to retain the position gained.

In some species of clematis we find a mechanism which reminds one of a simple hook-climber, but is in reality a much better arrangement. The young leaves projecting outward and slightly backward from the stem may remind us of the hooked spines of a bramble, and like them easily catch on neighboring objects, and support the trailing stem. Or the leaf of the species of clematis given in Fig. 1 may serve as an example of a leaf acting like a hook. The main stalk of the leaf is seen to be bent angularly downward at the points where each successive pair of leaflets is attached, and the leaflet at the end of the leaf is bent down at right angles, and thus forms a grappling apparatus. The clematis does not, like the bramble, trust to mere growth, to thrust itself among tangled bushes, but possesses the same powers of revolving in search of a support which simple or true twining plants possess. Indeed, many species of clematis are actually twining plants, and can wind spirally up a stick placed in their way. And the same revolving movement which enables them thus to wind spirally also helps them to search for some holding-place for their hook- or grapple-like leaves, and in many species the search is carried on by the leaves swinging round, quite independently of the revolving movement of the stem on which they are borne.

* That is to say, the revolving movement is not sufficiently developed to be of practical importance. The same remark is applicable to the other cases in which I have spoken of the absence of revolving movement in the growing parts of plants.

If a leaf of a clematis succeed by any means in hooking on to a neighboring object, the special characteristic of leaf-climbing plants comes into play. The stalk of the leaf curls strongly over toward the object touching it, and clasps it firmly. It is obvious how great is the advantage thus gained over a mere hook. A leaf such as that shown

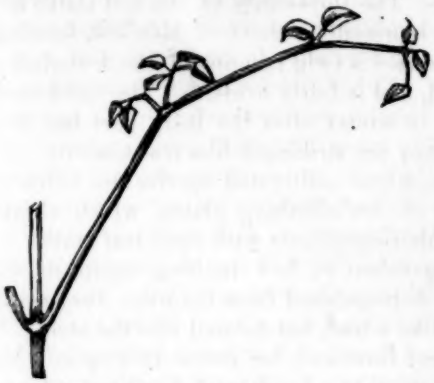

FIG. 1.*—A YOUNG LEAF OF CLEMATIS VITICELLA.

FIG. 2.—CLEMATIS GLANDULOSA, With two young leaves clasping two twigs, with the clasping portions thickened.

in Fig. 2 might be made to catch on to a neighboring twig by its bent stalk, in such a way that, although it managed to stay where it was, it could bear none of the weight of the plant, and would be liable to be displaced by a strong wind or other disturbance. But, when the stalk of the leaf had curled close round the twig, nothing could displace it, and it could take its share in the work of supporting the plant.

The extreme sensitiveness of the leaf-stalk to slight and gentle touches gives a curious idea of the alertness of the plant in its search for supporting objects. A leaf may be excited to bend by a loop of string weighing only one-sixteenth of a grain. It is an interesting fact that, in such a hook-like leaf as that of *Clematis viticella* (Fig. 1), the hooked end of the leaf, which has the best chance of coming into contact with obstacles, is the most sensitive part. This has been made out by hanging small weights on different parts of the leaf, and it is found that the terminal leaflet bends in a few hours after a loop of string weighing less than a grain is hung on it, and which produced no effect in twenty-four hours on the other petioles. One may see proof of the sensitiveness of the leaf-stalks of the wild English clematis, which sometimes catches withered leaves or delicate stalks of the quaking-grass. The same thing is shown by a leaf after having been touched with a little water-color, the delicate crust of dry paint being mistaken for something touching the plant. In such cases, or when the leaf has been merely rubbed with a twig, which is taken away before the leaf seizes

* For the loan of this and the other woodcuts illustrating this article, we are indebted to the kindness of Mr. Charles Darwin and Mr. Murray.

it, the plant discovers that it has been deceived, and, after bending for a time, it unbends and becomes straight again.

The bending, which enables a leaf to seize a twig, is not the only change which the stimulus of a touch produces. The leaf-stalk swells and becomes thicker and more woody, and turns into a strong, permanent support to the plant. The thickening of the leaf-stalks is to be made out in Fig. 2, which represents a shoot of clematis, bearing two leaves, each of which has seized a twig; in one of the leaf-stalks this thickening has commenced, and is fairly evident. The thickened and woody leaf-stalks remain in winter after the leafy part has dropped off, and in this condition they are strikingly like real tendrils.

The genus *Tropæolum*, whose cultivated species are often called nasturtiums, also consists of leaf-climbing plants, which climb like clematis by grasping neighboring objects with their leaf-stalks.

In some species of *Tropæolum* we find climbing organs developed, which can not logically be distinguished from tendrils; they consist of little filaments, not green like a leaf, but colored like the stem. Their tips are a little flattened and furrowed, but never develop into leaves; and these filaments are sensitive to a touch, and bend toward a touching object, which they clasp securely. Filaments of this kind are borne by the young plant, but it subsequently produces filaments with slightly enlarged ends, then with rudimentary or dwarfed leaves, and finally with full-sized leaves; when these are developed they clasp with their leaf-stalks, and then the first-formed filaments wither and die off; thus the plant, which in its youth was a tendril-climber, gradually develops into a true leaf-climber. During the transition, every gradation between a leaf and a tendril may be seen on the same plant.

FIG. 3.—BIGNONIA. An unnamed species from Kew.

It is not always the stalk of a leaf which is developed into the clasping organ; the bignonia-leaf shown in Fig. 3 bears tendrils at its free extremity. And in other plants tendrils are formed from flower-stalks, in which the flowers are not developed, or the whole stem of the plant or a single branch may turn into a tendril. In one curious case of monstrosity, what should have been a prickle on a sort of cucumber, grew out into a long, curled tendril.

The family of the *Bignonias* is one of the most interesting of the class of tendril-climbers, on account of the variety of adaptation which is found among them.

In the above-mentioned Fig. 3 is seen the tendril-bearing leaf of a species of *Bignonia*. The leaf bears a pair of leaflets, and ends in a tendril having three branches. The main tendril may be compared to a bird's leg with three toes, each bearing a small claw. And this comparison seems apt enough, for, when the tendril comes against a twig, the three toes curl round it like those of a perching bird.

Besides the toes or tendrils, the leaf-stalk is sensitive, and acts like that of a regular leaf-climber, wrapping itself round a neighboring object.

In some cases the young leaves have no tendrils at their tips, but clasp with their stalks, and this is a case exactly the reverse of *Tropæolum*—a tendril-chamber whose young leaves have no tendrils, instead of a leaf-climber whose young climbing organs are not leaves. Thus the close relationship that exists between leaf- and tendril-climbers is again illustrated.

This plant also combines the qualities of another class of climbers, namely, twiners, for it can wind spirally round a support as well as a hop or any other true twiner. Another species (*B. Tweedyana*) also helps to support itself by putting out roots from its stems, which adhere to the stick up which the plant is climbing. So that here are four different methods of climbing—twining, leaf, tendril, and root climbing—which are usually characteristic of different classes of climbing plants, combined in a single species.

Among the *Bignonias* are found tendrils with various curious kinds of sensitiveness. The tendrils of one species exhibit, in the highest perfection, the power of growing away from light toward darkness, just the opposite to the habit of most plants. A plant, growing in a pot, was placed so that the light came in on one side. One tendril was pointing away from the light, to begin with, and this did not move; but the opposite tendril, which was pointing toward the light, bent right over and became parallel to the first tendril. The pot was then turned round, so that both pointed toward the light, and they both moved over to the other side, and pointed away from the light. In another case, in which a plant, with six tendrils, was placed in a box, open at one side, all six tendrils pointed like so many weathercocks in the wind—all truly toward the darkest corner of the box. These tendrils also showed a curious power of choice. When it was found that they preferred darkness to light, it was tried whether they would seize a blackened glass tube, or a blackened zinc plate. The tendrils curled round both these objects, but soon recoiled and unwound with what, my father says, he can only describe as disgust. A post with very rugged bark was then put near them; twice they touched it for an hour or two, and twice they withdrew; but at last one of the hooked tendrils caught hold of a little projecting point of bark; and now it had found what it wanted. The other branches of the tendril quickly followed it, spreading out, adapting themselves to all the inequalities of the surface, and creeping into all the little crevices and holes in the bark. Finally a remarkable change took place in the tendrils: the tips which had crept into the cracks swelled up into little knobs, and ultimately secreted a sticky cement, by which they were firmly glued into their places. This plan of forming adhesive disks on its tendrils is one which we shall find used

by the Virginia creeper, as its only method of support, and it forms the fifth means of climbing to be met with among the *Bignonias*. We see now the meaning of the power possessed by the tendrils of moving toward the dark, for in this way they are enabled to find out and reach the trunks of trees to which they then become attached. It seems, moreover, that the tendrils are especially adapted to the moss- or lichen-covered trees, for the tendrils are much excited by wool, flax, or moss, the fibers of which they can seize in little bundles. The swelling process is so delicate that, when two or three fine fibers rest on the end of a tendril, the swelling occurs in crests, thinner than a hair, which insert themselves between and finally envelop the fibers. This goes on so that the ball at the end of a tendril may have as many as fifty or sixty fibers imbedded in it, crossing each other in different directions.

The tendrils of the Virginia creeper may here be worth noticing. This plant can climb up a flat wall, and is not adapted to seize sticks or twigs; its tendrils do occasionally curl round a stick, but they often let go again. They, like bignonia-tendrils, are sensitive to the light, and grow away from it, and thus easily find out where the wall lies up which they have to climb. A tendril which has come against the wall is often seen to rise and come down afresh, as if not satisfied with its first position. In a few days after a tendril has touched a wall the tip swells up, becomes red, and forms one of the little feet or sticky cushions by which the tendrils adhere, and which are shown in Fig. 5. The adherence is caused by a resinous cement secreted by the cushions, and which forms a strong bond of union between the wall and the tendril. After the tendril has become attached it becomes woody, and is in this state remarkably durable, and may remain firmly attached and quite strong, for as many as fifteen years.

Besides this sense of touch, by which a bignonia-tendril distinguishes between the objects which it touches, there are other instances of much more perfect and incomprehensible sensibility. Thus some tendrils, which are so sensitive that they curl up when a weight of one-thirtieth or even one-fiftieth of a grain is placed on them, do not take the least notice of a shower of rain whose falling drops must cause a much greater shock to the tendrils.

Again, some tendrils seem to have the power of distinguishing between objects which they wish to seize and their brother tendrils which they do not wish to catch. A tendril may be drawn repeatedly over another without causing the latter to contract.

The tendrils of another excellent climber (*Cobæa scandens*) possess some curious properties. The tendrils are much divided, and end in delicate branchlets, as thin as bristles, and very flexible, each bearing a minute double hook at its tip. These are formed of a hard, woody substance, and are as sharp as needles; a single tendril may bear between ninety and a hundred of these beautiful little grappling-hooks.

The flexibility of the tendrils is of service in allowing them to be blown about by a breath of wind, and they can thus be made to seize hold of objects which are out of reach of the ordinary revolving movements. Many tendrils can only seize a stick by curling round it, and this even in the most sensitive tendril must take a minute or two; but with *Cobæa* the sharp hooks catch hold of little irregularities on the bark the moment the tendril comes into contact with it, and afterward the tendril can curl round and make the attachment permanent. The importance of this power of temporary attachment is shown by placing a glass rod near a cobæa-plant. Under these conditions the tendrils always fail to get hold of the glass, on which its grapple-like hooks can not seize.

The movement of the little hook-bearing branches is very remarkable in this species. If a tendril catches an object with one or two hooks, it is not contented, but tries to attach the rest of them in the same way. Now, many of the branches will chance to be so placed that their hooks do not naturally catch, either because they come laterally, or with their blunt backs against the wood, but after a short time, by a process of twisting and adjusting, each little hook becomes turned, so that its sharp point can get a hold on the wood.

The sharp hook on the tendrils of *Cobæa* is only a very perfect form of the bluntly curved tip which many tendrils possess, and which serves the same purpose of temporarily holding the object caught until the tendril can curl over and make it secure. There is a curious proof of the usefulness of even this blunt hook in the fact that the tendril is only sensitive to a touch on the inside of the hook. The tendril, when it comes against a twig, always slips up it till the hook catches on it, so that it would be of no use to be sensitive on the convex side. Some

FIG. 4.—A caught tendril of *Bryonia dioica*, spirally contracted in reversed directions.

tendrils, on the other hand, have no hook at the end, and here the tendrils are sensitive to a touch on any side. These tendrils led my father at first into a curious mistake, which he mentions in his book. He pinched a tendril gently in his fingers, and, finding that it did not move, concluded it was not sensitive. But the fact was that the tendril, being touched on two sides at once, did not know which stimulus

to obey, and therefore remained motionless. It was in reality extremely sensitive to a touch on any one of its sides.

There is a remarkable movement which occurs in tendrils after they have caught an object, and which renders a tendril a better climbing organ than any sensitive leaf. This movement is called the "spiral contraction," and is shown in Fig. 4, which represents the spirally contracted tendril of the wild bryony; it may also be seen in Fig. 5, which represents the tendrils of the Virginia creeper. When a tendril first seizes

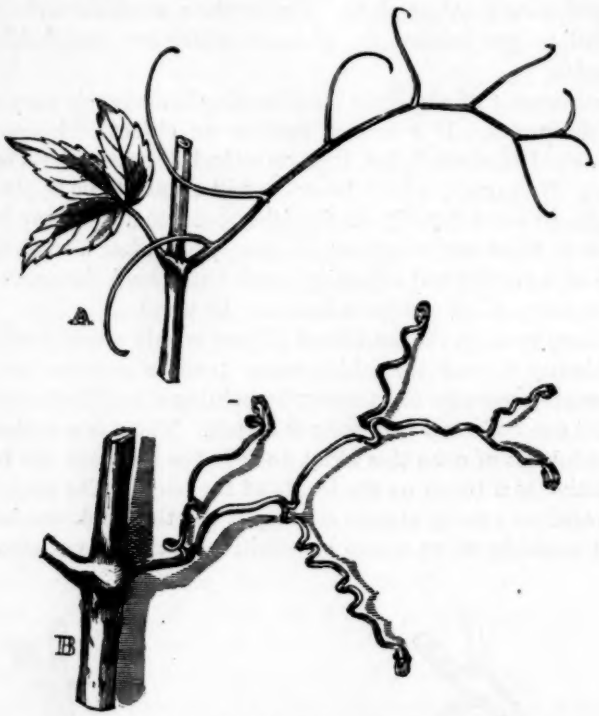

FIG. 5.—AMPELOPSIS HEDERARIA. A. Tendril fully developed, with a young leaf on the opposite side of the stem. B. Older tendril, several weeks after its attachment to a wall, with the branches thickened and spirally contracted, and with the extremities developed into disks. The unattached branches of this tendril have withered and dropped off.

an object it is quite straight, with the exception of the extreme tip, which is firmly curled round the object seized. But in a day or two the tendril begins to contract, and ultimately assumes the corkscrew-like form represented in the figures. It is clear that in spirally contracting the tendril has become considerably shorter; and, since the end of the tendril is fixed to a branch, it is obvious that the stem of the bryony must be dragged nearer to the object which its tendril has caught. Thus, if a shoot of bryony seizes a support above it, the contraction of the tendril will pull up the shoot in the right direction. So

that in this respect the power of spiral contraction gives a tendril-climber an advantage over leaf-climbers which have no contracting power, and therefore no means of hauling themselves up to supporting objects.

But the spiral contraction of tendrils has another use, and this is probably the most important one. This use depends on the fact that a contracted tendril acts like a spiral spring, and is thus converted into a yielding, instead of an unyielding, body. The spirally-wound tendril yields like an elastic thread to a pull which would break the tendril in its original condition. The meaning of this arrangement is to enable the plant to weather a gale which would tear it from its support by snapping the tendrils, if they were not converted into spiral springs.

My father describes how he went in a gale of wind to watch the bryony on an exposed hedge, and how, in spite of the violent wind which tossed the branches of the plant about, the bryony safely rode out the gale, "like a ship with two anchors down, and with a long range of cable ahead, to serve as a spring as she surges to the storm." It may also serve to divide the weight which has to be supported equally among a number of tendrils; and this is the meaning of the spiral contraction seen in the tendrils of the Virginia creeper.

It can be seen in Fig. 4 that all the coils of the spiral are not in the same direction. First, there are two in one direction, then six in the other, and then three again in the first direction, making six turns in one way and five in the other. And this is universally the case; the turns in one direction are always approximately equal in number to those in the opposite direction. It can be shown to be a mechanical necessity that a tendril which has its two ends fixed, and which then coils into a spiral, should behave in this way.

A simple model made to show this mechanical necessity is described by Sachs in his "Text-book." It is made by stretching a strip of India-rubber and cementing it to an unstretched strip. The strips being united in a state of longitudinal strain, form a spiral when released. If the model is held by one end only, the turns of the spiral are all in one direction. And this represents the behavior of a tendril which has not managed to seize a support; for some unknown reason such tendrils contract into spirals, and the turns of such spirals are all in one direction. But, if the India-rubber is held at both ends, half the turns are in one direction, half in the other, just as with a tendril the same thing happens.

Now, let us consider the general relations that exist between twining plants, leaf-climbing plants, and tendril-climbing plants. To an evolutionist the question how these various classes of climbing plants have been developed is perhaps of most interest. What is the relationship between them? Have all classes been developed separately from ordinary non-climbing plants, or has one class been developed out of one of the others; and, if so, which is the oldest form of climbing plant?

There can be little doubt on this latter point. I think we may certainly say that the earliest form which existed was a twining plant. We see that twining plants do not possess the essential feature of leaf- or tendril-bearers, namely, the sensitiveness to a touch which enables a leaf or tendril to grasp a stick. But, on the other hand, most leaf- and tendril-climbers do possess the essential quality of a twiner—the power of revolving or swinging round, which exists in the shoots, leaves, or tendrils of so many of them. This power of revolving merely serves in some leaf- and tendril-climbers to carry on the search for supports; but other leaf- and tendril-climbers, as we have seen, do actually wind spirally round a stick exactly like a true twiner. How twiners originally obtained their power of swinging round we need not now inquire; it seems to be merely an increase of a similar movement which is found to occur in a meaningless manner in other plants. Thus several flower-stems have been observed bowing themselves over and swinging round in small circles, like climbing plants. Here the movement is merely an unintelligible concomitant of growth, for, as we see, the movement is of no advantage to the flower-stem. But the existence of this movement is of great interest to us, for it shows how a twining plant might be developed by a similar movement being found to be advantageous, and being increased by natural selection to the requisite extent.

Another question which may occur to us is this: In what way is climbing by leaves or tendrils a more perfect method than twining? Why, when a plant had become a twining plant, did it not rest satisfied? The fact that leaf- and tendril-climbers have been developed out of twiners, and not *vice versa*, is a proof that climbing by leaves or tendrils is a more advantageous habit than twining; but we do not see why it should be so. If we inquire why *any* plant has become a climber, we shall see the reason. Light is a necessity for all green plants; and a plant which can climb is enabled to escape from the shadow of other plants with a far less waste of material than a forest-tree, which only pushes its branches into the light by sheer growth. Thus the weak, straggling stem of a climbing plant gets all the advantages gained by the solid, column-like tree-trunk. If we apply this test—which is the most economical plan of climbing, twining, or leaf-climbing—we see at once that a plant which climbs by seizing wastes far less material than one which twines. Thus a kidney-bean, which had climbed up a stick to a height of two feet, when unwound from its support was found to be three feet in length, whereas a pea which had climbed up two feet by its tendrils was hardly longer than the height reached. Thus the bean had wasted considerably more material by its method of climbing by twining round a stick, instead of going straight up, supported by its tendrils, like the pea. There are several other ways in which climbing by tendrils is a much better plan than twining. It is a safer method, as any one may convince himself by comparing

the security of a tendril-bearer in a heavy wind with the ease with which a twiner is partly blown from its support. Again, by looking at those leaf-climbing plants which still possess in addition the power of twining, it will be seen how incomparably better they grasp a stick than does a simple twiner. And again, a twiner from being best fitted to climb bare stems often has to start in the shade, whereas a leaf- or tendril-climber can ramble for the whole extent of its growth up the sunny side of a bush.

We can thus see plainly how it has been an advantage for twining plants to develop into leaf-climbers. We shall also find reasons why a leaf-climber should find it advantageous to become a tendril-climber.

We have seen how tendrils form a more sensitive, efficient grasping organ than simple leaves. Tendrils possess also the valuable power of shortening themselves by spirally contracting, and thus pulling up after them the stem on which they grow, and afterward serving as springs and breaking the force of the wind. We have had some cases where we see the close relationship between leaf- and tendril-climbers, and where we can see intermediate stages in the process of transition from one method of climbing to the other.

In certain kinds of *Fumaria* we can follow the whole process. Thus we have one kind, which is a pure leaf-climber, grasping by its leaf-stalks, which bear leaflets not at all reduced in size. A second genus has the end leaflets very much smaller than the rest. A third kind has the leaflets reduced to microscopical dimensions; and, lastly, a fourth kind has true and perfect tendrils. If we could see the ancestors of this last kind we should undoubtedly have a series of forms connecting it with an extinct leaf-climber, resembling the series which at present connects it with its contemporary leaf-climbing relatives.

To repeat once more the steps which it is believed have occurred in the evolution of climbing-plants: It is probable that plants have become twiners by exaggerating a swinging-round or revolving movement, which occurred in a rudimentary form, and in a useless condition, in some of their ancestors. This movement has been utilized for twining, the stimulus which has driven the process of change in this direction having been the necessity for light.

The second stage has been the development of sensitive leaves by a twining plant. No doubt at first no leaf-climber depended entirely on its leaves—it was merely a twiner which helped itself by its leaves. Gradually the leaves became more perfect, and then the plant could leave off the wasteful plan of growing spirally up a stick, and adopt the more economical and more effective one of pure leaf-climbing.

Finally, from sensitive leaves were developed the marvelously perfect tendrils which can perceive one fiftieth of a grain, and can show distinct curvature within twenty-five seconds after being touched, tendrils, with delicate, sticky ends, or endowed with the power of moving toward the dark, or of creeping into little cracks, or with that mys-

terious sense of touch by which a tendril can distinguish a brother tendril from an ordinary twig, and can distinguish the weight of a drop of rain hanging to it from a bit of thread—in short, all the delicate contrivances which place tendril-bearers so eminently at the head of the climbing plants.

There is only one more fact connected with the evolution of climbing plants which must be alluded to, namely, the curious way in which the representatives of the class are scattered throughout the vegetable kingdom. Lindley divided flowering plants into fifty-nine classes, called Alliances, and in no less than thirty-five of these climbing plants are found. This fact shows two things: First, how strong has been the motive power—the search after light—which has driven so many distinct kind of plants to become climbers; secondly, that the power of revolving, which is the first step in the ladder of development of the power of climbing, is present in an undeveloped state in almost every plant in the vegetable series.—*Popular Science Review.*

ÆSTHETIC FEELING IN BIRDS.

By Professor GRANT ALLEN.

THERE is no portion of Mr. Darwin's great superstructure which has been subjected to more searching criticism than his theory of sexual selection—the theory that beauty in animals is dependent, in part at least, upon the choice of brightly colored, ornamented, or musically endowed mates by one or other sex among all the more highly developed classes, such as insects, crustaceans, birds, and mammals. Not only have opponents argued strongly against the existence of such æsthetic tastes in the lower animals as would account for the supposed preference for beautiful partners, but even many of those who accept the evolutionist hypothesis as a whole have declared themselves unable to give in their adhesion to this particular speculation. Professor Mivart has brought forward strong objections to the great naturalist's view, and Mr. A. R. Wallace has raised a counter-theory on the subject of coloration at least, which has done much to convince many wavering biologists, and to insure their rejection of the suggested cause as adequate for the production of that beauty which all alike recognize in the animal world. It seems to me, however, that a little too much stress has been laid upon the notion that comparatively advanced intelligence is necessary for the appreciation of beauty in the opposite sex. It is true that our own highly complex æsthetic feelings are largely composed of elevated intellectual and emotional elements; but it may perhaps be shown that æsthetic tastes quite sufficient for the production of the known results do actually exist in many cases, and consist

almost entirely of very simple sensuous factors. In order for a butterfly or a humming-bird to admire its gorgeously appareled mate, it is not necessary that it should be capable of taking delight, like ourselves, in a Claude or a Rubens; it is enough that it should possess a nervous organization pleasurably affected by certain forms and colors in the same way as it is pleasurably affected by sweet fruits or the nectar of flowers. Nothing more than this need be postulated in order to establish the facts for which Mr. Darwin has contended with such wealth of illustration in the second part of the "Descent of Man."

It may be worth while, then, to examine a single large class of animals, in which the æsthetic nature is highly developed, for the purpose of discovering whether they do really afford proof of a sensibility to form, color, or musical sound. It must be remembered that even in our own race the sense of beauty in children, savages, and the uncultured classes, hardly rises above this simple level. We must not, of course, expect to find an appreciation of musical harmony, of imitative pictorial skill, of elaborate ornamentation, among birds or insects. We must be content if we see evidence of a love for red, blue, and yellow, for sweet perfumes and pleasant flavors, for symmetrical forms and simple patterns, for ringing notes and trilled resonances. The class of birds probably shows external marks of such tastes in a higher degree than any other; and, though many of them have been set forth by various writers elsewhere, it will perhaps repay the trouble to collect them into a single paper in order to show their bearing upon the general æsthetic sensibility of the class, as well as upon the specific question of sexual selection. For this purpose I shall first take for granted the fact of such selection, and afterward endeavor to justify it by analogy from known human practice.

Beginning with the lowest of the special senses, taste, we find ample evidence that very many birds have a strong liking for sugar. In confinement, canaries and parrots eagerly devour it in the manufactured form. In the wild state humming-birds, sun-birds, honey-suckers, lories, and many other species, feed off the nectar of flowers, more or less mixed with insects. Mr. Webber, an American naturalist, found that the ruby-throats of the United States were attracted by a cup of sirup, and numerous other birds display a strong liking for the same mixture. Fruits, which have been developed especially to suit the tastes of birds, almost always contain an abundance of sugary juices; while the kernels within their stones are generally bitter, so as to prevent their winged allies from devouring the actual seed. Hence we may infer that all the vast tribes of toucans, hornbills, macaws, plantain-eaters, birds-of-paradise, and fruit-pigeons, possess a taste for sugar sufficiently strong to have produced the separate evolution of these sweet seed-coverings in a hundred different families of plants throughout the whole world. Indeed, the strength of the evidence thus afforded can not be overrated, when we remember that

in every case the covering is a dead loss to the plant, except in so far as it aids the dispersion of seeds; and that it must have been developed over and over again in a thousand different cases by the action of the most widely different birds. It is impossible to believe that such a coincidence can be due to accident, impossible to doubt that it results from a genuine taste for sweet flavors.

There is even some reason to believe that birds care for and discriminate other tastes besides the fundamental distinctions of sweet and bitter. All the small birds in Jamaica are particularly fond of the little scarlet capsicums grown in gardens, and devour them so greedily, that the fruit has acquired the common name of *bird-peppers*. If we remember how very hard is often the almost horny covering of a bird's tongue, there is nothing remarkable in the fact that the pungency of the capsicum should be felt as an agreeable stimulant, probably having effects analogous to those of mustard, water-cress, or peppermint, with human beings. The oft-quoted liking of tropical pigeons for the nutmeg, with its aromatic coating of mace, points in the same direction. Parrots in captivity frequently display very decided preferences and antipathies in their food. Owls can not be induced to taste meat in the slightest degree tainted. Again, all birds have a most accurate notion of the difference between ripe fruits and the unripe sour ones, besides carefully choosing the sunny side of peaches, pears, and apricots. The very frequency of distinct sapid principles in fruits would seem to favor the same supposition, as they have probably been acquired for the special allurement of particular species. Indeed, the more we consider the origin and nature of succulent fruits, the more does it become clear that they have been developed to suit the tastes of animals having essentially identical sensations with our own.

The case of the nutmeg leads us naturally on to the consideration of smell. Here we may conclude with great probability that the large class of aromatic fruits has acquired its perfume for the sake of attracting birds, especially when we recollect that flowers have acquired exactly similar perfumes for the sake of attracting insects. And although the possession of scent as a means of sexual allurement is rare among birds, being probably confined to the musk-duck and a few other species, yet it occurs frequently among butterflies, and is represented among mammals by the musk-deer, beaver, and many other ruminants or rodents. Curiously enough, the similarity of taste thus testified extends to the vegetal world in the case of the musk-plant; while even certain carnivores, such as the cat tribe, are extremely fond of "valerian, lemon-thyme, camomile, lavender, and many plants rich in essential oils." On the other hand, a good observer notes that cats have their dislikes, and he has often seen a tabby "smell at a fig-tree, and turn away with the disgusted air of a connoisseur." We have no such strong facts in the case of birds, but the frequency of perfumes in those fruits which depend upon them for the dispersion of their seeds, coupled

with their total absence among most nuts, would lead to the conclusion that their likes and dislikes in the matter of smell are fully as marked.

But it is when we arrive at the sense of hearing that we come to the point where proper æsthetic feelings begin. It is quite impossible to doubt that birds are fond of musical sounds. The song of our own nightingales and linnets, the deep notes of the South American bell-bird, the incessant cooing of the dove, the noisy chattering of the parrots, the ringing cry of the whippoorwill, all lead to the same conclusion. Here, again, these sounds are of precisely the same nature as those employed by the crickets, katydids, cicadas, and other musical insects, as well as by man himself in his vocal and instrumental music. Something of the same taste is displayed among the quadrumana by the howlers and other monkeys. But it is a noteworthy fact that large majority of these presumably sexual calls, in birds, insects, and other animals, are true musical sounds, not mere noises. I have pointed out elsewhere the probable reason for this preference of pure tones in the case of mankind; and the same argument will apply, *mutatis mutandis*, to all other animals. But there is certainly a singular analogy in this respect between sounds and colors, most animals preferring the relatively pure and simple musical tones to confused noises; and the relatively pure and simple analytic colors, red, blue, green, and yellow, to confused mixtures such as brown, gray, and mud-color. At any rate, a bird evidently pays far more attention to the musical class of auditory perceptions than to mere noise. A canary will take no notice of ordinary confused sounds in a room; but, if one begins to chirp or whistle to it, it immediately responds with another chirp in emulation. So, too, when a piano or other musical instrument is played in the neighborhood of a singing bird, it will often show its recognition of the musical character by pouring out its very fullest flood of song, as if to conquer its unconscious rival. Of course, the singing-matches between birds themselves are too familiarly known to call for separate mention. It may be worth while, however, to notice that this love of musical sound exists even among certain reptiles; for I have often seen the common house-lizard of Jamaica listening with evident interest and attention to the playing of a piano, turning his head from side to side, and scampering away when disturbed, only to return again to the fascinating sound after a minute or two of hesitation.

The cases of the starling, the piping bullfinch, and the mocking-bird, which can be taught to whistle a tune, show the same power still more highly developed. These instances prove not merely susceptibility to musical sounds, but also a capacity for distinguishing the harmonic intervals. It is stated that some birds, even in the wild state, display considerable knowledge of the musical scale; and a San Francisco naturalist is at present engaged upon a work in which he hopes to show that the human ear possesses in this respect merely a

more highly developed form of the common vertebrate sensibility. When we reflect upon the purely physical and physiological basis which, as Helmholtz has taught us, underlies the musical intervals and the distinctions of harmony and discord, there is certainly no reason why they should not be perceived by all the higher animals alike, in a greater or less degree.

Considering, therefore, the evident susceptibility of birds to the simpler pleasures of music, and the interest which they show in it even apart from their domestic relations, there is no *a priori* difficulty in accepting the belief that their powers of song may have been developed by mutual selection, provided no adverse argument can be shown against the probability of such selection ever proving a cause of specific variation. To this last question, the question so ably raised by Mr. Wallace, I shall return on a later page.

Passing on to sight, we have first to observe the effects of mere light or brilliancy upon birds, apart from special effects of color or form. Now, birds certainly share with insects and many other creatures the common fascination for bright lights. "Owls and night-jars have been known to flutter against the window of a lighted room in the small hours." * In the tropics, where windows are more constantly left open, birds frequently fly into houses, attracted by a lamp or candle. The reflected light of a mirror is employed to draw down larks. Magpies delight in secreting diamonds, gold, silver, and other shiny objects. The bower-birds use shells, polished pebbles, and like brilliant odds and ends in the construction of their bowers. So, too, metallic iridescence occurs frequently in the feathers of beautiful species, notably in the humming-birds, sun-birds, peacocks, and other flower-feeding or fruit-eating classes. But even the far less brilliant crows, gulls, ducks, and doves show exquisitely burnished gloss or luster on their coats, often specialized upon particular portions of the plumage, and apparently betraying the action of sexual selection.

Of the love for color shown by birds, I have already treated so fully elsewhere, that it will suffice here briefly to recapitulate the main facts. The universality of bright hues in the fruits which depend upon birds for the dispersion of their seeds clearly shows that fruit-eating species are attracted by red, blue, purple, and yellow; just as the analogous case of insect-fertilized flowers shows the preference of bees and butterflies for similar tints. Mr. Darwin has collected several instances of interest displayed by birds in colored objects, and of the attractiveness which color evidently possesses in their eyes. Of these, the most remarkable cases are those of the bower-birds' and the humming-birds' nests. And the constant occurrence of very brilliant hues among flower-feeding species, such as humming-birds, sun-birds, lories, and barbets, or among fruit-eaters, such as toucans, fruit-pigeons, birds-

* This, with several other instances, I take from an interesting article on "The Senses of the Lower Animals," in the "Quarterly Journal of Science" for July, 1878.

of-paradise, and parrots, induces the belief that in these classes the exercise of the structures upon the search for food has led to the formation of a very strong taste for color, ultimately resulting in sexual modifications.

As for the harmony of color usually observable in birds, it must be remembered that our feeling of harmony probably depends upon the due intermission and alternation of sense-stimulants, and therefore ought naturally to be shared by us more or less definitely with all other animals having a like constitution of the eye. Now, the mammalian and avian eye being derived from a common ancestor, who already possessed a highly developed power of vision, we might reasonably expect that our feelings of harmony would be essentially identical; and this expectation is fully borne out both by the coloration of fruits and of birds themselves, which seldom or never present what we should regard as discordant coloring. Furthermore, as the most beautiful classes of birds are those which live perpetually among tropical flowers and fruits, in the most beautiful forests or meadows, surrounded by exquisite insects and reptiles, and for ever exercising their vision upon the most diversely colored environment in the whole world, it would seem far from impossible that their chromatic sensibility is even more highly developed than that of average humanity, and therefore that harmony or discord of colour would bear a relatively greater importance in their eyes than in those of any human being except the most artistically endowed. This conclusion will doubtless sound strange and even grotesque to those who are always accustomed to postulate for man a kind of absolute supremacy in the scheme of Nature; but it appears to me almost as obvious and as simply accounted for as the superiority of scent in the dog and the deer, or of distant vision in the eagle and the vulture. Lastly, it may be noted that much of the beauty of birds, as of insects, fruits, and flowers, is due to the delicate gradation of tints which they display. But in all natural products such gradation is an almost necessary result of the mode by which they have been evolved. It is only in human manufactures, where pigment is laid on with a brush or stamp, that colors can be placed in crude juxtaposition to one another, giving rise to the worst form of chromatic discord. Doubtless our native feeling of dislike to such discords, based upon their immediately fatiguing effect upon the nerves employed, has been heightened intellectually by the knowledge that they differ so widely from the dainty gradations to be found in the handiwork of Nature. Besides being sensuously recognized as discordant, they are intellectually recognized as inartistic. Thus a large part of our art-progress has consisted in an advance from the harsh and monotonous fields of primary red and blue, divided by very hard and definite lines, which we find in Egyptian painting, to the faithful representation of graduated tints and shades which appears upon a modern canvas. But in the petal of a rose, the ray of

a daisy, the wing of a butterfly, the tail-covert of a peacock, such gradual merging of tint in tint could hardly fail to occur spontaneously, as a product of evolution; while the comparatively definite marking off of special spots or lines, as in some orchids and other flowers, could only present itself as a result of very intense competition between species, carried on under highly complex conditions. The views set forth by Mr. Bates upon the progressive modification of patches or regions in a butterfly's wing, and by Mr. Darwin and Mr. Wallace on the feathers of the peacock and the Argus-pheasant, though widely differing as to the particular mode of their evolution, yet alike convince us that the inevitable result must be just such a graceful running together of contiguous colors as we actually find to obtain in every case.

Lastly, we arrive at the sensibility to form, symmetry, arrangement of patterns, and the like higher sensuous æsthetic feelings, which remains in the eyes of many the chief stumbling-block in the way of accepting the theory of sexual selection. The pleasure derived from sweet tastes and fragrant perfumes is so purely sensuous that nobody doubts its universal existence among all the higher animals. The pleasure derived from musical sounds and bright colors, though more intimately bound up in the human consciousness with intellectual and higher emotional elements, yet contains so large a factor of mere sensuous stimulation that we can easily conceive of it as appealing to the ears and eyes of insects and vertebrates. But the still higher pleasure derived from graceful curves, symmetrical ornamentation, and elaborate tracery is so largely made up of intellectual feelings, and so largely supplemented in our own case by associations of costliness, human handicraft, or imitative skill, that we find it hard at first sight to believe in the existence of similar feelings among pheasants of the Indian jungle, antelopes of the African plains, or monkeys of the Brazilian forest. Even here, however, a little consideration may convince us that the æsthetic appreciation of form and its connected varieties is not necessarily above the narrow intellectual faculties of the higher vertebrates and articulates at least.

In the first place, if we look at the human race itself we shall find that a comparatively high susceptibility to form occurs even among very low races. Indeed, most exquisite patterns are produced by savages whose taste in color is apparently far less developed than that of parrots, humming-birds, and fruit-pigeons. The tattooed tracery of the Polynesians and many other savage tribes presents beautiful designs of which even a European decorative artist need not be ashamed. The New Zealand canoes, the paddles and clubs of the Admiralty-Islanders, the shields of the Zooloos, are all most graceful in their shapes and most daintily wrought with interlacing patterns in carved work. Calabashes, cocoanuts, ostrich-eggs, and other early vessels are always cut in sections which exactly coincide with the demands of the most

developed taste. The huts of savages are generally square, circular, or oval in shape, neatly wattled at symmetrical distances. The earliest architecture consists of regular stone rings, avenues, tumuli, and other definitely shaped monuments. Dr. Schweinfurth's "Heart of Africa" contains pictures of pottery as beautiful as anything ever produced in Greece or Etruria, stools, chairs, and other furniture as gracefully shaped as anything ever wrought by a Renaissance carver, and villages as prettily arranged after their simple fashion as the architects of the Parthenon or Cologne could have arranged them. If we look back in time, we find the stone hatchets and arrow-heads, not only of the neolithic but even of the palæolithic age, carefully symmetrical in shape, and that at a time when the extra labor of chipping the flints into comeliness must have entailed a considerable waste of human or half-human energy. At the same early date we find fossil shells, symmetrical bones, teeth, and other like objects, already drilled to serve as necklaces or other ornaments, which analogy with the similar ornaments now in use would lead us to believe were symmetrically strung together into definite patterns. Indeed, the more we look at the products of the very lowest savages and the very earliest men, the more shall we be convinced that they possessed in the germ all those æsthetic feelings which have finally developed our existing architecture and other decorative or semi-decorative arts.

Again, we can not fail to be struck by the fact that man has always employed for ornamental purposes exactly those very appendages of animals which, if the theory of sexual selection be correct, have been produced by the animals themselves as ornamental adjuncts. The feathers of peacocks, the plumes of the ostrich and the bird-of-paradise, the antlers of deers, the horns of antelopes, the tusks of elephants, mammoths, and musk-deer, the striped, spotted, or dappled skins of mammals, all these have been used from the earliest periods as materials for decoration by mankind. Exactly the same curls, twists, and patterns which seem to please the eyes of animals are known to please the eyes of man, even in his lowest developments. If these ornaments were not produced because the creatures themselves found them beautiful, at least they are the same as those which would have been produced had the taste of such creatures coincided in the main with that which runs throughout the whole of humanity, from the most degraded savage to the highest artist.

Moreover, part at least of the pleasure of form probably has a purely sensuous origin. The superiority of curved lines to straight, of the waving or sinuous contour to the angular, is apparently connected with the muscular process in the act of vision. Hence there is no reason why it might not be felt by intelligent animals, just as we know that it is felt, and acutely felt, by hardly more intelligent men.

Similar conclusions are forced upon us if we look at the nature of the supposed ornaments themselves. They are almost always, like the

horns of several ruminants, the tail-coverts of the peacock, and the lappets or crests of many birds, apparently devoid of any functional use whatsoever, unless that use be the attraction of the opposite sex. They are also marked by the extreme definiteness of their shape, color, or sculpture—a definiteness which never occurs in similar structures among the lower animals. For though some echinodermata, as for example the sea-urchins, are very beautifully and regularly marked, yet their markings are purely dependent upon the structural arrangements of the animal, and can not generally be detected till after death. So, too, the shells of many mollusca, such as scalaria and the murices, are very beautifully sculptured; but this sculpture is structurally necessary for the animal, and apparently depends entirely upon the shape and markings of the mantle. Among birds, however, as among the ruminants, all the structures ascribed by Mr. Darwin to sexual selection are marked by a kind of definiteness, quite unconnected with ordinary functions, which it is difficult to describe in words, but which can immediately be *felt* if we compare the coloration of a peacock with that of a sea-anemone or a medusa. The former is perfectly definite without being obviously connected with structure; the latter is very indefinite, and yet bears a clear relation to the general shape of the animal. This combination of great specific distinctness with little apparent functional value appears to me the genuine hall-mark of organs due to sexual selection.

There is even some little external evidence in favor of a love for symmetry among birds. The nests of weaver-birds and many other species, as well as the bowers of the bower-birds, display a considerable taste for orderly arrangement. For one must remember that the building of such nests, though doubtless instinctive and inherited, is not a mere organic process, like the secretion of a molluscan shell; it is as much an art as the building of a honeycomb or of a savage hut. The flight of birds in play, the antics of many humming-birds, the strange eddyings and aërial evolutions of several other species, all approach very nearly to our own idea of dancing. I am almost afraid to hazard the observation, yet on the other hand I can not avoid risking it, that the attitudes taken up by the turkey-buzzards or Johncrows of the West Indies upon the tops of houses frequently seemed to me intentionally symmetrical. I have observed them sitting in every variety of position—one at each end of a long roof; one at each of the two points half-way between ends and middle; three arranged in either of these forms, with one in the middle; five arranged in the order C, B, A, B, C, etc. If any other observer can supplement this experience, which I record with great diffidence, I shall be very glad.

Taking for granted, then, this appreciation of form and symmetry, we shall find that it has produced many notable effects in the world of birds. To it, apparently, we owe the crests of cockatoos, pigeons, herons, and a hundred other species; the wattles, combs, hackles, and

lappets of the gallinaceous birds; the beaks of toucans, hornbills, and cassowaries; the wonderful marking of the peacock and the Argus-pheasant. Any one who wishes really to understand the immense variety of ornamentation which has thus resulted should pay a visit to the ornithological rooms in the British Museum, and observe the innumerable devices for attracting attention which exist in almost every order of birds. Perhaps the familiar lyre-bird offers the very finest example of all, so far as beauty of form and symmetry of arrangement are concerned. It is specially noticeable, however, that in almost every case the decorations are lavished on the very same parts on which they would have been bestowed by human taste.

If, then, we put together all the scattered indications thus afforded us, if we consider the taste for sweet food and delicate perfumes, the song of the nightingale and the graceful movements of the swan, the metallic colors of the flower-feeders, the exquisite hues of the fruit-eaters, the varied plumage of the birds-of-paradise, the beautiful nests and bowers, the habit of abstracting brilliant objects, the universal loveliness of shape or tint throughout the whole class—we can hardly doubt that birds, as a whole, possess æsthetic endowments of a very high order. Let us proceed to consider the general bearings of these views upon the question of sexual selection.

Mr. Herbert Spencer, in a very remarkable essay upon personal beauty, has shown that in the human race we regard as beautiful, on the whole, just those personal peculiarities which are, roughly speaking, the external marks of fitness for the conditions of human life. More especially do we admire those points which bespeak a *physique* adapted for the duties of paternity and maternity. We dislike excessive leanness or excessive fat; a sallow or a bloated complexion; deformity or extreme departure from the normal type. On the other hand, we like in man robust and muscular limbs, an erect carriage, an open chest, a virile development of beard and whiskers, with all the other outward signs of health and strength. We like in woman a womanly and tender face, a fine and well-developed figure, and all the other outward signs of health, and more especially of healthy maternal capacities. We like in both sexes an abundant crop of hair, clear and bright eyes, white and well-set teeth, red lips, and cheeks which show a good and sound circulation; we like an expression which betokens good humor, moral qualities, and refinement; lastly, we like a face which indicates intellectual power and ability to succeed in the highly complex struggle for life in the midst of which our lot is cast. One or other of these points we may occasionally waive in consideration of other special claims; but if anybody asks in the abstract whether we prefer a stunted *physique* to well-grown limbs and muscles; a flat-chested woman to one with a finely-proportioned bust—unhealthy and sallow skin to a clear complexion; a sour-looking, mean, or brutal face to a bright, joyous, open, and honest countenance; silly

or idiotic features to an expression full of liveliness and intelligence—there can be but one answer possible. Leaving out of consideration for the present all other elements of the involved and complex problem, we may conclude that beauty, from one point of view at least, consists for each species in the outward signs of specific adaptation to specific necessities.

On the other hand, beauty also consists from a different point of view of stimulation by a certain relatively fixed number of external stimulants—musical sound, brilliant light, analytic colors, curved shapes, symmetrical arrangements of form, etc.—which appear to act directly upon the nervous system. This is clearly the view which Mr. Darwin implicitly accepts, especially with regard to tone and color. The facts at which we have briefly glanced above respecting the æsthetic feelings in birds, and the beauty of the birds themselves, take for granted some such theory of the æsthetic faculty. How are we to find a reconciliation between this view and that of Mr. Herbert Spencer?

I believe the true clew has been given us by Mr. A. R. Wallace, in the able essays on "Color in Plants and Animals" which originally appeared in "Macmillan's Magazine," and were afterward reprinted in his work on "Tropical Nature." It is true that Mr. Wallace utterly rejects sexual selection as a *vera causa*, and substitutes for it several separate minor modifications of natural selection; yet it seems to me that a compromise between his view and the two other views of Mr. Darwin and Mr. Herbert Spencer would more really represent the actual state of the case in nature. Or, to put it more correctly, the three ideas are not in reality contradictory or even opposite, but are rather different and complementary aspects of one and the same fundamental truth.

Beauty in the abstract and for all species, as it seems to me, consists of pleasurable stimulation of the higher sense-organs. Such pleasurable stimulation must, on the average of cases, be given rather by brilliancy than by dullness; rather by analytic colors than by confused hues; rather by curved or flowing forms than by angularity; rather by musical sounds than by mere noises. But beauty relatively to the particular species, and especially as regards the sexual relation, must be largely due to special inherited tastes, doubtless ingrained and physically registered in the nervous system, leading the animal to derive pleasure from the typically healthy and normal form of the opposite sex. For, if any individual possesses divergent tastes, they must either be for relatively unhealthy and typically defective forms, in which case they will tend to be promptly suppressed by natural selection; or for neutral or improved forms, in which case they will help to give rise to new varieties, ultimately culminating in separate species. Such divergent tastes seem to be shown in all large dominant families, such as the humming-birds, where specific variation and ornamentation

have been carried out to a very great extent. But all such divergent fancies must themselves tend to become distinctly fixed for purposes of specific identification; and we find as a matter of fact that each species does readily recognize its mates, even when the differences between closely allied species are only very slight.

Now, this special hereditary liking for a particular form and type will not interfere with the general love for color, brilliancy, sweet tones, and perfumes. Accordingly, wherever the circumstances which give rise to a taste for these sense-stimulants exist, it would naturally follow that the taste would help to determine the choice of mates. But, again, as Mr. Wallace has fully shown, the most vigorous individuals would usually possess the most highly developed ornaments, the brightest colors, the largest scent-glands, and the loudest or most musical voices. Hence the very animals most likely to be sexually selected are also, on the average, those most likely to be naturally selected. Yet sexual selection really differs from natural selection, in that it gives a special direction to the ornamentation. For example, one can hardly believe that mere masculine vigor will account for the gorgeous and positively inconvenient plumage of the bird-of-paradise, nor for the exquisite coloring of the peacock, nor for the extremely ungainly air-bladders of many insects. It is quite easy to conceive that the general vigor implied by the possession of these extended ornamental adjuncts may have helped their possessors in the general struggle for life; but it is hardly possible to believe that they could have reached their present definite development without the aid of sexual selection. In short, where an ornament, or what seemed to any particular individual an ornament, proved hurtful to the race, it would be eliminated by natural selection; but where it proved neutral it would be spared, and if it coincided with advantageous qualities it would be further developed. Yet, even if only neutral, sexual selection alone would give it an extra chance, and, as it would doubtless be correlated on the one hand with certain special tastes and habits, and on the other hand with certain slight modifications of structure, it would doubtless succeed on an average of cases in producing a new species.

The familiar facts of human beauty will probably serve to make this reconciliation of the conflicting views a little clearer. Man of course admires in the abstract bright colors, brilliancy, musical notes, graceful curves, and symmetrical form. But, as applied to the human face and figure, he admires these in certain special and typical arrangements. Thus, while our general love for color leads us to prize golden hair, we do not like a sallow complexion; while it leads us to see beauty in rosy cheeks and red lips, which are signs of a healthy circulation, we do not admire the same redness in the nose, where it is usually a result of dyspepsia or dissipated habits, either of which is bad for the race at large. Again, though we admire pearly teeth, clear eyes, and a white skin, all of which are obviously the external

marks of useful properties, we do not admire white cheeks, which are the external mark of weakness or anæmia. Similarly, our idea of beauty demands that the figure should neither be too fat nor too thin, but should possess that graceful development of all the muscles which is the outward symbol of ability to move and act with ease and effect. If any large number of persons were ever actuated by opposite tastes, if they preferred pale cheeks and lips to rosy ones, thin and haggard faces to full and rounded ones, weak and angular limbs to strong and graceful ones, a flat and undeveloped chest to a fine and healthy bust, then they and their taste must rapidly die out through the inferior *physique* they would hand on to their descendants. And as every individual is himself the product of countless thousands of prior individuals, all of whom have been in the main successful in the struggle for life and the search for mates, it must follow that he will have inherited from them, on the average, a healthy taste for that particular arrangement of limbs and features which best suits the essential conditions of the species. Not, of course, that he will consciously recognize this fact in most cases; but the mere presentation of such a typical combination will instinctively rouse in him, through the organized correlation of nervous centers, the hereditary feeling of beauty. Hence this feeling will probably be most strongly aroused in each species by the sight of the sex which in that species has undergone the greatest differentiation through sexual selection: just as we know that the feeling is most strongly aroused in mankind by the beauty of woman. On the other hand, we are still able to perceive, when we look at a peacock or a humming-bird, that, though this specific hereditary feeling is absent, yet the strength of the purely abstract elements—color, brilliancy, symmetry, form, and minute workmanship—is so unusually great that we have no hesitation in pronouncing them also beautiful after their kind.

If, then, we admit the reality and potency of sexual selection, in however modified a form, it must follow that birds, being on the whole the most ornamental of all classes in the animal world, are also the most æsthetic, with the exception of man. It might, at first sight, seem that consistency would demand the sacrifice even of this exception; but a moment's reflection will disclose an important difference between the two cases. Man possesses the active power of direct artistic creation; the birds only possess the passive power of selection from among the forms produced for them by Nature. The ordinary workman who selects his wife partly or wholly on the ground of beauty, thereby does something toward perpetuating and improving the beauty of the race; he stamps the impress of his taste upon future generations; but such mere passive choice differs widely from the ability to depict or create on canvas such a beautiful woman. In this way, the actual loveliness of birds may lead us somewhat to over-estimate their æsthetic sensibility; for, though within their own species they may be

capable of distinguishing between comparatively minute shades and degrees of beauty, just as we can distinguish between such minute points in human faces as would doubtless absolutely escape the notice of any other animal, it is yet improbable that they would be equally discriminative outside the limits of their own species. Again the principle of "gradation of characters" necessitates certain artistic effects in their plumage which they themselves may be only half able to admire. So, too, the necessarily symmetrical arrangement of the two sides of the body and the mode of growth of feathers may often have helped, unintentionally, as it were, in producing the total effect. In other words, it may well be that the birds, while selecting their partners on the ground of bright color, exceptionally long plumes, and other ornamental characters which they *could* understand and admire, may have succeeded in producing harmonies of tone, delicate gradations of tint, and other similar effects which they could *not* understand or admire, or at least could only admire very partially.

Yet, after making all allowances for possible reading in of human feelings, it may probably be asserted with safety that the actual appearance of birds entitles them to rank, on the whole, higher in the æsthetic scale than any other animals except man. Whether we look at their graceful shapes, in the swan and the heron; their beautiful plumes, in the ostrich and the bird-of-paradise; their exquisite color, in the sunbird and the lory; their ornamental crests and lappets, in the humming-birds, the pigeons, and the parrots; or their song in the linnet, the mocking-bird, and the nightingale—we must confess that they give extraordinary evidence of a taste for all that man considers lovely or artistic. And this is just what we might expect from their free mode of life, their rapid motion, their highly developed senses, their comparative freedom from enemies, their long and almost uninterrupted rivalry between themselves for the possession of their mates. Especially should we expect this splendid outburst of æsthetic sensibility exactly where we find it in its greatest glory, among the flower-haunting and fruit-eating species of the Brazilian forests, the Indian jungles, and the Malay Archipelago. Surrounded for generations and generations by gorgeous orchids and trumpet-creepers, from which they sucked the stored-up nectar, by gleaming purple or golden fruits, by burnished beetles, metallic butterflies, bronze-scaled lizards, and coral snakes, their prey or their enemies, exercising their eyes perpetually in the search for food among the exquisite objects of their environment, and safe from almost all foes except those of their own class, tropical birds have naturally developed the most gorgeous and the most perfect forms and colors in the whole animal creation. And, above all, they have stamped the mark of their peculiarly high æsthetic feelings upon their own shapes by the wonderful definiteness of their patterns and their ornamental adjuncts, nowhere equaled, save in the most perfect decorative handicraft of man himself.

ELECTRICITY AND AGRICULTURE.

By Dr. PAGET HIGGS.

M. L. GRANDEAU, Professor in the School of Forestry, of France, was the first to point out definitely the influence of atmospheric electricity on the nutrition of vegetation.

His labors are described in the "Annales de Chimie et de Physique," for February, 1879, and he there gives the results of experiments carried out in 1876–'78.

These experiments are little known, but are of the highest importance to agriculture. As they bear upon similar experiments undertaken by the writer, a *résumé* is merited. M. Grandeau was led, from the common observation that the underwood in a dense forest disappears, to consider the influence of trees on the vegetation beneath them. Studying the causes generally assigned in explanation of this natural phenomenon, such as diminution of light, and the influence of the green light reflected by the trees, these appeared to him insufficient, and he concluded that the loss of electricity, due to the trees acting as an electrical screen, was the cause of the retarded growth—a theory that his experiments, as well as those of M. Mascart, ultimately confirmed.

The experiments consisted in placing plants under similar conditions of soil, light, and water, but covering one plant with a cage of iron-wire netting of very large mesh, the netting acting as a faradic cage, or somewhat as a lightning-conductor; the wires of the netting were one fiftieth of an inch in diameter, and the mesh six inches by four. Illustrative of the effect of this arrangement, the case may be cited of two tobacco-plants, otherwise under similar conditions:

	Without Cage.	Under Cage
Total height	1·05 metre	0·69 metre
Number of leaves	14	10
Weight of fresh leaves	107 grammes	70 grammes

Chemical analysis showed defective nutrition in the plant placed under the cage, and withdrawn from electric influence. These experiments were greatly extended, and trials were made as to the relation of electrical effect and nitrification of the soil, and the assimilation of the ammonia of the atmosphere by plants. The results are summed up by M. Grandeau as follows:

"That trees withdraw, for their own profit, electricity from the atmosphere, and insulate, as completely as a metallic cage, the plants they cover. Insulation produced by a high tree can extend to the extreme limits of its foliage. A plant withdrawn from the influence

of atmospheric electricity is subject to marked retardation in its development, so that the quantity of living substance in insulated vegetation is from thirty to fifty per cent. less than the production in free air.

"The transformation of chlorophyllic protoplasm into glucose, etc., appears particularly influenced by atmospheric electricity.

"Flowering and fruit-bearing are subject equally to modification. Electricity does not appear to favor the direct combination of the nitrogen of the air with oxygen, nor with the hydrocarbons of the soil; but it exercises a remarkable influence on the nitrification of the nitrogenized matters of the soil by the intervention of the plant as an electrical conductor. Atmospheric electricity is, therefore, a preponderating factor in vegetable production."

These considerations induced the writer to carry out a series of experiments to ascertain the effect on vegetable development of a surcharge of electricity.

It would appear, from the primary consideration of intensified electrical conditions existing in tropical climates, that the more rapid growth of tropical vegetation might be due to higher electrical force. To the resident in tropical climes such a proposition would be beyond the limits of theory, because of the constant observation of the great development in vegetation during and immediately after a thunderstorm.

The experiments undertaken by the writer gave results that leave no doubt that the growth of vegetation may be enhanced twenty-five to fifty per cent. by the judicious application of electricity.

These experiments consisted in placing upon two marble slabs, one of which was carefully insulated, ten plants of the kind under trial. On the insulated slab was raised an iron structure with depending points, arranged to discharge into the atmosphere surrounding the plants the electricity produced by an induction-machine at an estimated potential of about four thousand to five thousand volts. This arrangement and difference of electrical condition, other conditions being the same, were maintained day and night for eight months, resulting in unmistakable increase in the development of the surcharged plants. The practical application of electricity to the hastening of the development of vegetation is easy. Above the plants or among them may be placed a number of metallic points on a framework insulated from the earth. Wires carried by small balloons—India-rubber or collodion bladders filled with gas—to a considerable elevation would collect sufficient of the electricity of the atmosphere, which would be imparted to the points, and these would discharge slowly to the earth, saturating the atmosphere in the neighborhood of the plants. The cost of such an arrangement would be small, and that great advantages are to be obtained from it is undoubted.

ZOÖLOGICAL EDUCATION.*

By Professor W. S. BARNARD.

IT is the office of education to direct the mental growth of the individual; and this should be by a developing and not by a cramming process. In our present system there is too much burdening of the verbal memory, and too little of what may be called the objective memory, resulting from the exercise of the mind upon actual objects. What we want is more observation, more inductive reasoning, judgment, understanding—in short, intelligent thinking; but how little do we find of this in the prevalent method of education in institutions of all grades!

Ordinary courses of study do not include subjects upon which these various mental activities can be sufficiently employed. They consist too much in learning rules pertaining to language and mathematics and their deductive applications, and too little in the objective investigation of things, the making of generalizations and the investigation of laws. School facts and deductive sciences are means instrumental to business success; but they are not in themselves sufficient to carry on the work of mental development. But, even where natural science is taught in public schools, it is generally for a short time, late in the course, and by the old method of memorizing or parroting from books instead of making it a constant study of concrete objects, to which some time should be devoted on two or more days of each week throughout the student's whole career. This learning of nature from books alone is an impossibility, a deception, and a fraud, like the teacher's "can't for want of time and specimens," when the crops are suffering from insects which swarm everywhere, and the chief amusements of the boys are to go hunting and fishing.

Teachers should utilize what they can obtain by the help of students. This is dangerous for the unfitted instructor, because he will be constantly approached with new specimens and with questions he can not answer. Yet it is better to have books of reference at hand and look things up, or have the student do it, than to be robbed of the benefit. I knew a Western teacher who formed a class of students every year in some study of which he knew little or nothing, in order that he himself might be profited by learning with them. Those who teach other things well may venture to strike out boldly and improve themselves in some part of natural history of which they were ignorant at the outset; because it is better to swim than sink, though of course a good preparation is preferable.

No field is better calculated to improve the inductive functions

* Read at the University Convocation, Albany, New York, July 13, 1880.

than that of zoölogy—the highest department of biology—while some of its divisions are to be highly recommended on account of their great economic importance. The agriculturist has to deal directly and practically with only the two highest branches of the animal kingdom, with the jointed animals known as vertebrates and arthropods. To the first of these man himself belongs, and it is now admitted that the best and most practical way to acquire a knowledge of human physiology, anatomy, and development, is by studying the comparative physiology, anatomy, and embryology of vertebrates. Also, because our domestic animals belong to this group, with many of our friends among the birds, snakes, lizards, salamanders, toads, and fishes, it deserves special study. To the second branch belong the crab-like animals, the myriad-legged forms, those which are spider-like, and true insects, which are the highest of their branch. These we meet everywhere, at every step. They are the most abundant of all organisms, their number of species exceeding that of all other animals, with all the species of plants taken together. Every terrestrial plant and animal has its insect-pests, and these in turn have insectean destroyers, which are indirectly friends to the animal or plant. With the cultivation of extensive areas, the destruction of beneficial insects, of birds and reptiles, and their forest-homes, with the introduction of new food-plants, and adaptive changes in the food-habits of insects, we favor the multiplication of our native pests, while to these we have added through commerce all the foreign marauders which can be brought with imported produce, and without the enemies which retard their increase in their own countries. At least thirty species of our most objectionable insects are derived from the Old World, among which are the dreaded currant-worm, the cabbage-worm, the cabbage-fly, the Hessian fly, the wheat-midge, the bee-moth, the apple-worm, the cabbage-lice, grain-weevils, the house-fly, the European cockroach, carpet and clothes moths and bugs, the asparagus-beetle, and the clover-beetle. This group is commanding more and more attention by the great increase of its depredations from year to year.

For all these reasons, insects appear in near and important relations to man. On these accounts, but also because of the endless variety of wonderful and interesting habits and instincts among them, is their study especially recommended. Not only is the natural history of such creatures of practical value, but there is a peculiar fascination in its study that is highly beneficial in its influence, aside from the pleasure it affords. This is expressed by J. B. Hartwell as follows: "My soul is vexed, from day to day, because the writers of unrighteous fiction are so popular, while the devotees . . . of science and the promulgators of God's truths are to such a degree neglected, their writings unsought, unread. Yet not wholly so. I rejoice to believe that the number of students in the school of Nature is rapidly increasing. And I devoutly pray and hope that the beauties and attrac-

tions of nature may be so unfolded and presented that the youth of America may be turned from the unprofitable, innutritious, and demoralizing food of fiction to the bread and water of a true life."

The facts, details, and technicalities of this science are too immensely numerous to be taught with any great degree of thoroughness, except to such as make a life-specialty of the study. Yet a knowledge of its most interesting and important facts, principles, and methods, unencumbered with a strict scientific nomenclature, can be so quickly imparted as to bring it within temporal possibilities.

All educational institutions, and public schools especially, should be *required* to teach vertebrate and entomological zoölogy in a thorough manner, while the general characteristics of the other branches and a few of their more common and curious representatives should be briefly studied in addition.

The only way to bring practical entomology to agricultural minds generally, to the class with whom it is of greatest importance, is to *require* that it be taught in all public schools. It is a kind of knowledge which the young country student grasps easily and successfully when deprived of its unessential technicalities. Of such practical consequence is it, that it had better be taught at the expense of almost any other study of the usual courses, and some attention to it would be a great relief from unnecessary problems in abstractions which are often inflicted to a useless extent in early training.

It is a sad result of the failure to teach natural science in the public schools that our cultivators do not recognize their own interest and duty with reference to insects, and need to be forced by law to a sense of its importance, even when they appear as a great scourge and leave famine in their trail. Entomological legislation with respect to the locust plague in the West, like the German insect-laws ("Abraupgesetzen"), has been to a considerable extent beneficial, though it is often difficult to force the execution of such laws. There are strong reasons why we should have a set of insect-laws for all the States. They would be as useful and as easily enforced as the "game-laws," and those prohibiting the harboring of certain noxious plants, or of nuisances against which boards of health are organized. Only by some such arrangement can farmers be compelled to coöperate for their own interests and successfully combat the thieves which are robbing them of their produce, for there are plenty whose sense of obligation can only be aroused through government influence, and who will not educate themselves in this subject unless forced to it. Laws, even if not executed successfully, instruct the people as to their duties. We need legislation to enforce—1. The teaching of entomology and vertebrate zoölogy. 2. Coöperation in destroying insect-pests. 3. The protection of beneficial insects. 4. The protection of useful birds and their eggs, whether game-birds or not, throughout the entire year.

Where can the schools and teachers get the incentives and helps

they need to prosecute the work proposed for them? They can obtain these through the influences of legislation, of educational boards, and of our higher institutions of learning. Members of educational boards especially should see that this new work be introduced and continually performed.

Here will naturally arise the question, What is being done in this line at Cornell University? Besides the general course in zoölogy, there are special courses pertaining to vertebrates and insects. In the anatomical department, the special anatomy of the domestic cat is worked up as a standard of comparison, and is followed by the anatomy of examples of the leading groups and of the domestic animals, while in the entomological department special attention is devoted to those insects which are most injurious or beneficial, or otherwise, of unusual interest. Our very complete collections illustrating these insects and their habits in all their stages of transformation exhibit almost everything pertaining to the subject, and are in glass cases where they can be studied at all times. Instruction is also given in the use of antidotes and other devices for opposing objectionable kinds. At the same time students may elect in any term special and advanced courses in—1. Economic entomology. 2. Systematic work on the classification of some group. 3. Comparative anatomy and histology of insects; or, 4. Comparative embryology and metamorphoses of insects or insect-biologies. These zoölogical studies are conducted with reference to their practical relations to the cultivation of crops, to the breeding and medical treatment of domestic animals, to human physiology and hygiene, and to the doctrines of evolution.

THE ENGLISH PRECURSORS OF NEWTON.

THE seventeenth century must be regarded as the most memorable in the history of science; our own age has been remarkable for the skillful application of scientific analysis, but it has not produced a Bacon and a Galileo, a Harvey and a Newton. Between 1600 and 1700 theoretical knowledge received an increase far outweighing in importance the sum total of what has been achieved between 1700 and the present time. The definitive acceptance of the true theory of the world, and its triumphant establishment on a basis of universal and harmonious law; the constitution of physiology as a science by the great discovery of the circulation of the blood; the vast stride made in mechanics by the clear recognition of the laws of motion; the knowledge of the fundamental truths relating to light and color; the foundation of the sciences of magnetism, electricity, and chemistry—are all due to that period. The nineteenth century is not more pre-

eminent for the invention of mechanical agencies by which the external conditions of human life have been revolutionized than the seventeenth for the production of those momentous "aids to sense"*—the telescope, microscope, barometer, and thermometer—by which an indefinite series of new worlds have been annexed to the domain of human intelligence. In the abstract region of mathematics, the performances of the epoch under consideration are equally remarkable. By the invention of logarithms, calculation was hardly less expedited than communication has been in our time by the discovery of the electric telegraph; while the differential and integral calculus, through the enormous increase of power conferred by it, might not inappropriately be termed the steam-engine of the intellect. Yet, notwithstanding the utilitarian character of the prevalent philosophy, inventions of practical utility remained comparatively rare; and no advance, corresponding in any degree with that accomplished in science, was made in the comforts and conveniences of every-day life. Thus, by a singular irony, a generation which sought in its experiments "fruit," found "light"; while our own age, which, with the dying Goethe, demands "more light," has received, instead, "fruit" not always sweet to the taste.

To Englishmen the seventeenth century is rendered of peculiar interest by the circumstance that, during its course, the center of scientific progress was shifted, through the overwhelming force of genius, from the Continent to this island. When it opened, our countrymen were in the position of disciples; when it closed, they were recognized as the teachers of Europe. The advance made in the interval was enormous. In 1600 Tycho Brahe was still inculcating at Prague the geocentric theory of the universe; Galileo was expounding the "sphere" on Ptolemaic principles; Harvey was listening at Padua—the "*Quartier Latin* of Venice," as M. Renan has called it—to the cloudy conjectures of Fabricius as to the purpose served by the valves in the veins. In 1700 the "Principia" had been for thirteen years the common property of mankind; Newton was acknowledged as the arbiter of science by the greater part of the civilized world; the principles of mechanics were settled on the same footing on which they stand to-day; and the last cavil against the innovation of the Folkestone physician had long ago been forgotten. We propose, in the following pages, to sketch in its broader outlines the movement of thought which led to such great results, and to devote some brief attention to a man whose career was the most conspicuous failure of the century, and who, aspiring to play the part of the Octavius, was condemned to that of the Antony of science.

Dr. Robert Hooke not only was unable to "command success," but we doubt whether he could have conscientiously asserted that he deserved it. He was original, diligent, and ingenious; but he wanted

* "Novum Organum," lib. ii., Aph. xxxix.

the concentration, disinterestedness, and, above all, the indefeasible patience, which mark the highest order of minds. Among the contemporaries of Newton, he approached most nearly to and contrasted most strongly with that great man, whose shining qualities and achievements have been set off by the convenient foil of his rival's defects of temper and fortune. It may perhaps be possible to derive a larger lesson from the consideration of his life's work than the trite moral conveyed by his exhibition in the character of the captive in the car of triumphant genius. In Newton the epoch was idealized ; in Hooke it was simply reflected. We can study more conveniently the varying impulses and undefined aspirations of a period of transition and progress in the versatility which obeyed than in the steady purpose which transformed and dominated them. The greatest men are of all time ; the lesser are an epitome of their age. They pass with it ; but they teach in passing.

Hooke believed himself to be the disciple of Bacon ; but his real instructors were men of a widely different and far less pretentious stamp. Experimental science does not date, even in England, from the "Chancellor of England and of Nature." *Roma ante Romulum fuit.* The Egremont Castle of traditional knowledge shook, it is true, to its foundations at the formidable blast of this new Sir Eustace, and the Peripatetic usurper heard in it his knell. But the fortress was already dismantled ; a numerous and unrelenting foe had silently taken possession of its outworks and bastions, and, stone by stone, was busy turning the materials of the ancient stronghold to account in the construction of habitations of more modern aspect and accommodation.

Among the multifarious forms of activity stirred into life by the ferment of the Italian Renaissance, perhaps the least questionable in its results was that leading to the love and study of nature. Two men of singular genius, Leon Battista Alberti and Leonardo da Vinci, led the way ; and their example was followed by the astronomers, anatomists, physicians, and botanists, with whom, in the following century, Italy abounded. Mathematics were at the same time cultivated with signal success ; and the learned enthusiasm which, a hundred years earlier, had hailed the unearthing of a long-forgotten codex by Poggio or Filelfo, now greeted the solution of a problem by Cardano, or the discovery of a formula by Ferri or Tartaglia. Nor did these abstract inquiries remain long unfruitful. The questions which had busied the brain of Archimedes at the siege of Syracuse began to emerge from the neglect of wellnigh eighteen centuries, and the "mechanical powers" of lever, pulley, screw, and inclined plane were once more, as our neighbors say, the order of the day. The movement was now no longer limited to the sub-Alpine peninsula. Simon Stevin, of far-away Bruges, and Michael Varro, of Geneva, deserve to be named, with Benedetti, of Venice, and Del Monte, of Pesaro, as the precursors of Galileo, whose strongest title to fame is that he first brought natural

investigations under the rigid but salutary yoke of the sciences of number and of space.

In England the same impulse made itself felt, although, amid the religious troubles of the time, its effects were at first obscure and intermittent. It is, however, much to the credit of our national sagacity and boldness that, within a few years of the publication of Copernicus's great work, three Englishmen were found to advocate doctrines so novel, so startling, and so repugnant to ordinary experience as those contained in it. The introduction into England of the new views in astronomy was, in all probability, due to the notorious Dr. John Dee, the favored soothsayer of Elizabeth and Leicester, whose reputation as a mathematician has been eclipsed by his fame as a magician. His career aptly illustrates an old proverb, exhibiting the evil effects on later life of a bad name gratuitously bestowed in youth. The suspicions roused by his ingenious contrivance of an automaton-scarabæus, which, during a performance of the "Pax" of Aristophanes, visibly mounted upward carrying a man and a basket on its back, seem to have tickled his inordinate vanity, and, more than thirty years later, he hired a certain Edward Kelly to instruct him in occult arts at a salary of fifty pounds a year. Himself a dupe, he was the fitter to dupe others; and succeeded for a time in imposing his pretensions on several of the greatest personages in Europe. At length he and his spiritualistic pedagogue were compelled to retire to the castle of Trebonia, in Bohemia, where Kelly's supposed mastery of the great alchemistic secret procured them such affluence that, according to the popular belief, Dee's young son was accustomed to play at quoits with gold produced by means of the "philosophical powder of projection." Finally, the confederates quarreled; Dee was recalled to England by Elizabeth, and receiving, after the manner of that princess, more promises than pay, died in poverty in the fifth year of her successor. He left, for the benefit of posterity, a detailed record of his supernatural communications; and the magic crystal which he professed to have received from the hand of an angel may still be seen, together with Robert Burns's punch-bowl, and a casket carved out of Shakespeare's walnut-tree, among the curiosities preserved in the British Museum.

It is, however, as an astronomer, not as a spiritualist, that we have to do with him. In 1547, four years after the promulgation of the Copernican theory, he visited the Low Countries for scientific purposes, and subsequently lectured and studied at the Universities of Paris and Louvain. We may safely conclude that he there acquired the convictions which led him to instigate, and patronize with a preface, the publication of John Field's "Ephemeris" for 1557, *juxta Copernici et Reinholdi canones*. This performance has earned for Field the title of the "Proto-Copernican of England," justly due, no doubt, to the first English astronomer who adopted, *ex professo*, the heliocentric theory of the solar system. But, in a book which appeared probably

a few months earlier, the same views were upheld as unhesitatingly, if not so systematically. Its author was more ingenious than fortunate. What is most certainly known of his life is its unhappy end. Robert Recorde was an eminent physician as well as an able mathematician. In his medical capacity he is believed to have been attached to the households of Edward VI. and Mary, and he undoubtedly died in a debtor's prison, the year of Elizabeth's accession. He has the merit of having introduced algebra—or, as he termed it, "Cossike Practice"—into England in a book named "The Whetstone of Witte," represented by Scott as constituting the sole literary possession of old Trapbois the miser, and as inspiring, by its very title, the young Lord of Glenvarloch with such a lively aversion that not even the desolation of a night in Alsatia could induce him to seek solace in its pages. The same writer's "Castle of Knowledge" might have proved a more efficacious remedy for *ennui*. It is an astronomical dialogue, the progress of which is enlivened by some touches of quaint satire. We take from it the following extract, noteworthy as (so far as we know) the first printed reference in the English language to the memorable innovation of the Canon of Frauenburg:

Master. Copernicus, a man of great learning, of much experience, and of wonderful diligence in observation, hath renewed the opinion of Aristarchus Samius, and affirmeth that the earth not only moveth circularly about his own centre, but also may be, yea and is, continually out of the precise centre thirty-eight hundreth thousand miles; but because the understanding of that controversy dependeth on profounder knowledge than there in this introduction may be uttered conveniently, I will let it pass till some other time.

Scholar. Nay, sir, in good faith, I desire not to hear such vain phantasies, so far against common reason, and repugnant to the consent of all the learned multitude of writers, and therefore let it pass for ever, and a day longer.

Master. You are too young to be a good judge in so great a matter: it passeth far your learning, and their's also that are much better learned than you, to improve (disprove) his supposition by good argument, and therefore you were best to condemn nothing that you do not well understand; but another time, as I said, I will so declare his supposition, that you shall not only wonder to hear it, but also peradventure be as earnest then to credit it, as you are now to condemn it.*

The objurgations of Giordano Bruno, on the occasion of his visit to Oxford in 1583, made, we can infer, but little impression on the hard-headed English Peripatetics of the time, and the Copernican system seems to have receded rather than advanced in credit during the last twenty years of the century. "How prove you," asks Blundevile in his "Exercises" (published in 1594), "that there is but one world?" "By the authority," he unhesitatingly replies, "of Aristotle!" and the inertia of his ignorance is noways shaken by his own admission that

* "The Castle of Knowledge," p. 165. London, 1556. Quoted also by Professor De Morgan, "Companion to the British Almanac for 1837," p. 36.

Copernicus, "by help of his false supposition, hath made truer demonstrations of the motions and revolutions of the celestial sphere than ever were made before." *

Already, however, the Aristotelian dictatorship was being undermined, where it could not be overthrown. William Gilbert of Colchester, physician to Queen Elizabeth (whom he only survived a few months), deserves to be called the founder of experimental science in England. In his treatise "De Magnete," published in 1600, he brought together a copious store of facts, the result of his own patient investigations, and connected them by a consistent theory, thus starting the science of electricity on a career still full of promise for the future. He was not only a Copernican, but anticipated Galileo in an important correction of the Copernican theory, pointing out the fallacy by which a so-called "third movement" was considered necessary to account for the parallelism of the earth's axis of rotation.† In his youth he had studied on the Continent, and his works were there in great repute, while his own countrymen probably shared the half-contemptuous estimate of Bacon, who placed him but a degree higher than Paracelsus and the alchemists in the school of "fantastic philosophy."

With the opening of the new century, progress became more rapid. Harriot, the friend of Raleigh, made notable advances in algebra, and was among the earliest of telescopic observers; Napier published in 1614 his "Marvellous Canon of Logarithms"; and Harvey, whose theory of investigation was as sound as his practice was successful, began his immortal lectures "On the Motion of the Heart and Blood" in 1619. In the same year was born, at Toxteth, near Liverpool, a man whose name would assuredly have been as illustrious as it is now obscure, if a premature death had not cut short his labors before they had well begun.‡ Jeremiah Horrocks belonged to a Lancashire family of little pretension and less means. His puritanism was signified by his entrance at Emmanuel College, Cambridge, and his poverty by his admission as a sizar, May 18, 1632. A passion for astronomy early seized upon him, but his tastes met with neither encouragement nor cultivation at Cambridge, which at that time afforded no form of scientific training. Books were his sole instructors, and his slender resources the limit of his choice. Indeed, his short life was one continued struggle against the tyranny of material difficulties. After a residence of three years, he left the university, summoned home probably by domestic exigencies, and spent his remaining years in the daily treadmill of tuition, or some equally harassing occupation. He

* "Companion to the British Almanac for 1837," p. 43.

† "De Mundo nostro sublunari," lib. i., cap. xi., p. 165, published (posthumously) in 1651.

‡ There is no positive evidence in support of the tradition that Horrocks was born in 1619. The fact that he was in orders and held a curacy in 1639 throws a doubt upon his age, as men are not ordained at twenty.

found time, however, for astronomical observations, and in 1636 his zeal for his favorite pursuit was still further quickened by meeting with a congenial spirit in William Crabtree, a clothier of Broughton, near Manchester, one of a remarkable group of north-country mathematicians, to whom Fate was as unkind in the untimeliness of their deaths as in the obscurity of their lives. Encouraged by his new friend, Horrocks quickly exchanged the guidance of Lansberg for that of Kepler, henceforward the object of his enthusiastic but by no means undiscriminating devotion. Even in the Rudolphine Tables he discovered inaccuracies, trifling, it is true, in comparison with the boastful blundering of the reactionary Belgian astronomer, but requiring, nevertheless, careful correction; and in the accomplishment of this task he convinced himself that a transit of Venus, which Kepler had failed to predict, would actually occur on November 24 (O. S.), 1639. He had by this time taken orders in the Church of England, and been appointed to the curacy of Hoole, then a desolate hamlet situated on a strip of land half reclaimed from the overflow of the Ribble, about five miles south of Preston. It was here that, first among astronomers of all ages, he observed the passage of Venus across the sun.

The 24th of November fell on a Sunday, and, as the critical moment approached, the eager star-gazer was summoned from his telescope to his pulpit, returning, however, just in time to witness, as the clouds parted at a quarter-past three, the punctual verification of his forecast in the projection of the dark body of the planet on the solar disk. An interval of half an hour before sunset gave him time to make a series of observations surprisingly accurate considering the primitive character of the apparatus available for their execution. A telescope bought for half a crown, and a circle of six inches in diameter, traced with a pair of compasses on a sheet of paper, stood to the young curate of Hoole in the stead of all the complicated and exquisitely delicate instruments which form the intermediaries between the senses of a modern astronomer and the phenomena he observes. Horrocks did not long survive this solitary triumph of his life. After many postponements, he at length saw a prospect of one day's extrication from his conflicting employments, and fixed January 4, 1641, for a visit of science and sympathy to his friend Crabtree. On the morning of the 3d, however, he suddenly expired, thus exchanging, in a moment, his promised post among the radiant ranks of those who constitute the pride of humanity for a place in the pathetic company of "the inheritors of unfulfilled renown."

The career of Horrocks affords, throughout its course, a singular example of precocity. He matriculated at thirteen, was ordained at twenty, and died before he had completed his twenty-second year. On him, if on any man, might safely be passed the usually somewhat problematical eulogium, "He had done great things had he lived." His mind was as quick to catch the differences of things like as it was

capacious to gather the similarities of things unlike. To the imaginative fervor of Kepler he joined the technical skill of Tycho, and something of the experimental sagacity of Galileo. Short as was his life, and scanty his opportunities, he still left the imprint of his genius on astronomical theory. The movements of the moon had not yet been brought within the dominion of Kepler's Laws. Horrocks first pointed out that the apparent irregularities of our satellite could be harmonized into an orderly scheme, by supposing her to revolve in an ellipse of which the earth occupied one focus—the eccentricity of such ellipse being variable, and its major axis directly rotatory. Both these conditions Newton, in his investigation of the problem of three bodies, demonstrated to follow necessarily from the law of gravitation, thereby lending overwhelming corroboration to the views of his youthful predecessor. It has been unwisely said that Newton was indebted to Horrocks for the rudiments of his great generalization. No statement could be more misleading. The passage in his writings principally relied on for its support is indeed remarkable, as containing a description of an ingenious experiment, illustrative of the compound nature of the planetary movements, used afterward by Hooke, with a fuller understanding of the conditions of the problem; and some scattered indications may be found that the analogy between terrestrial gravity and the power exerted in the celestial mechanism was evident to him, as it had been to Gilbert, Bacon, and Galileo; but we are unable to discover that his idea of central forces was notably in advance of the crude notions current among his contemporaries.

Little as we know of Horrocks, we might easily have known nothing. His legacy to posterity barely escaped total annihilation. Some of his papers were destroyed in the civil war; some perished in the great fire of London; some were carried to Ireland, and there lost. A remnant only was preserved by the care of William Crabtree, and after his death (which followed quickly upon that of his friend) passed into the hands of Dr. Worthington, of Cambridge. Hevelius, the celebrated astronomer of Dantzic, eventually obtained possession of his "Venus in Sole visa," and published it in 1662, as an appendix to his own observations on the transit of Mercury. Whereupon the Royal Society, awakening to the merits of their countrymen, commissioned one of their most distinguished members to edit what could still be recovered of his writings, and even voted, we are told, five pounds toward the expense of printing. Dr. Wallis accomplished his task satisfactorily. The *disjecta membra* of the Horroxian manuscripts, organized into a tolerably consistent form under the title "Astronomia Keplerana Defensa et Promota," were given to the public in 1672, together with those fragments of his correspondence with Crabtree which, disguised in the uncouth Latin of the Savilian professor, constitute all our knowledge of the life of Jeremiah Horrocks.

We have already seen that his scientific enthusiasm was not an

isolated impulse. On all sides men were rising up eager to devote their best energies to physical inquiries; and society, whether fanatic or frivolous, animated them by its curiosity and rewarded them with its applause. The Long Parliament appointed, July 20, 1653, a committee "for the advancement of learning." Evelyn drew up, in 1659, an elaborate scheme for the foundation of a "philosophic-mathematic college." Cowley dismounted for a moment from his "Pindaric Pegasus" to make a "proposition for the advancement of experimental philosophy," whereby "the lost inventions, and, as it were, drowned lands of the ancients, should be recovered; all things of nature, delivered to us by former ages, weighed, examined, and proved; all arts which we now have improved, and others which we yet have not, discovered." * Samuel Pepys was scarcely less interested in astronomy than in the playhouse, and gossiped with as much zest about the experiments at Gresham College as about the pageants of Whitehall. Charles I. thought of founding a scientific repository at Vauxhall; the Earl of Worcester actually bought tenements there for the purpose; Sir William Petty recommended a comprehensive plan for the "interpretation of nature whereof there is so little, and that so bad, extant in the world." This design, "breathed after" (as Evelyn says) by so many, was, at least in part, realized by the foundation of the Royal Society.

This celebrated institution had its origin in the meetings of the "Invisible College," of which Robert Boyle, John Wallis, and Dr. Wilkins—afterward Bishop of Chester and author of a novel project for traveling to the moon—were members. It was in 1645 that these, with several other no less eminent men, began to seek in the so-called "new philosophy" a refuge from the turmoil of civil war, their scientific *symposia* being sheltered either in Gresham College or the less dignified retreat of the "Bull's Head" tavern, in Cheapside. Their fortunes were destined to expand. Fifteen years later they constituted themselves a society for the promotion of experimental science, and were incorporated by royal charter, July 15, 1662.

Thus the "Solomon's House" of the "New Atlantis" received a "local habitation" in Bishopsgate Street, and Bacon's splendid fable was brought to the test of actual, if only partial, embodiment in a living institution. Nothing can be more evident than the enormous influence exercised by the "incomparable Verulam" over the founders of the Royal Society. Not only were his praises celebrated among them, but his precepts were, as far as possible, obeyed by them. Their foreign correspondents acted the part of the "merchants of light" appointed to enrich the Island of Bensalem with the knowledge of other lands. The "mystery-men," "dowry-men," "pioneers," and "compilers" of Solomon's House had all their representatives among the "learned knot," who designed

* Weld, "History of the Royal Society," vol. i., p. 51.

"To make themselves a corporation,
And know all things by demonstration." *

Their offices, it is true, were not so sharply defined, nor the division of labor so strictly enforced, as in the ideal "College of the Six Days' Works"; but the actual never fails to blur the dividing lines of the imaginary. What it is important to observe is that Bacon's "prophetic scheme" did in truth kindle the fancy of the generation which succeeded him, and that his maxims swayed their purposes. What it is equally important to observe is that, in so far as they followed his method in its larger bearings, they were on the track of discovery, and already began to pick up stragglers from the great army of discoverable truths; but the moment they descended to particulars, and took him, as it were, at his word, they found themselves in a *cul-de-sac*. It was as if an astronomer, not content with imparting a means of taking the longitude, should attempt to prescribe rules for managing the ship, and the sailors, finding that flapping sails and fouled rigging invariably followed upon a literal compliance, should finally come to the conclusion to steer their course on scientific principles, but handle the ropes as nautical experience might suggest.

What, then, is the truth as regards the vexed question of Bacon's influence on the progress of science? We take it to be this: His capacious imagination enabled him to grasp, and his vast powers enabled him to guide, a movement which he had not originated. He caught up the floating ideas of his time, spread them abroad by his eloquence, sank them deep by his enthusiasm, gave them universality and consistence by his sagacity, and thus not unworthily earned the title of the "Father of the Inductive Philosophy." It must be confessed, indeed, that the great "Secretary of Nature" was entirely deficient in what we may call official training. His lucid thoughts and splendid diction were not coupled with exact knowledge or scientific experience. He was innocent of mathematics. He was grossly ignorant of astronomy. He knew nothing of Kepler. He despised Galileo. He passed over in silence the most fruitful discovery in physiological, and the most striking invention in numerical, science that had been made since the world began, although both were made in his own time. He ranked among the "idols" besetting the human mind that orderly instinct which recommends, *prima facie*, the harmonious simplicity of the Copernican hypothesis in preference to the outrageous complexity of the Ptolemaic system. He cumbered his phraseology and confused his argument by the adoption into physical reasoning of the metaphysical abstractions of the schools, and weakened his philosophy by the rejection of their deepest wisdom.

Bacon was in truth the English representative of that abortive but

* MS. verses signed "W. G.," quoted by Weld, "History of the Royal Society," vol. i., p. 79.

brilliant school of thought to which belonged Ramus, Patricius, and Bruno. His relations were far closer with the Cosentine than with the Lyncean Academy. As far as he was the disciple of any man, he was the disciple of Telesius, its founder. Although his name was commonly associated with that of the Tuscan astronomer as inventor of the philosophy of nature, he was in reality the English Campanella rather than the English Galileo. He was Campanella with a sounder understanding, a deeper insight, and a larger humanity. To Campanella's prophetic zeal he united incomparable practical sagacity. He not only preached a millennium of universal knowledge, but endeavored to guide men's halting footsteps toward the goal, and to bridge the gulf between the future toward which he pointed and the present to which he belonged. Hence his profound and persistent design was to establish a method, not to found a school. The message that he had it in him to deliver related to men's works, not to their thoughts. His speculative teaching not only was subordinate to his physical precepts, but was suggested by them, and displays the characteristic defects due to such an origin.

Thus his intellectual progeny divided itself into two classes—those who developed the philosophical principles implied rather than professed in his writings, and those who adopted, or endeavored to adopt, the scientific method of which the "Novum Organum" exhibits the majestic *torso*. Among the first we reckon Hobbes, Locke, and Hume in this country, and abroad, Bayle, Condillac, and the Encyclopedists —all of whom, while setting themselves problems which Bacon had ignored, and solving them, for the most part, after a fashion which Bacon would have repudiated, carried out, nevertheless, to their extreme conclusions doctrines in some degree countenenced by his great name. To the second class belonged Boyle, Hooke, Wren, and the other early members of the Royal Society. These men inherited the labors and the spirit of those who had worked while Bacon taught—of Harriot, Gilbert, Napier, and Harvey; but they were born while the air still vibrated to the mighty words of Verulam. They then enrolled themselves under the banner which he had unfurled, and silently followed the examples which he had condemned. They identified him with a system which he had disowned, and with acclamation proclaimed him leader of a movement which he had emphatically declared to be unfruitful. While professing to follow where he led, they in truth carried his authority captive with them along the paths they themselves chose. This, indeed, was the result, not of insubordination, but of necessity. They were compelled to seek a *modus vivendi* between the conflicting claims of Nature and her interpreter, and they found the conciliation that they sought not very far from the modest courses of their predecessors.

It is not too much to say that what was distinctive in Bacon's system was impracticable, and that what was practicable was already

common property. The essential novelty on which he relied for the infallibility of his mode of interrogating Nature was his method of exclusions. But this ingenious invention implied an impossible preliminary, and rested on a monstrous assumption. The preliminary to its successful operation was the compilation of what he called a "Natural History"; that is, an exhaustive catalogue of all natural phenomena, constituting a vast repository of materials for induction. Until this should be accomplished, he laid down dogmatically that no progress worthy the human race was possible,* and declared the history without the method to be infinitely more serviceable to science than the method without the history.† The assumption was that the infinite complexity of visible and sensible objects is formed by the varying combinations of a limited number of "simple natures" (such as heat, weight, color, etc.), just as words and sentences in endless diversity are compounded out of a few elementary signs.‡ And as, by learning six-and-twenty letters, we get at the secret of written language, so we have only to construct a complete alphabet of Nature, in order to read her riddles with ease and certainty. Thus the second step in the process was nothing less than to frame a synopsis of all the modes of action in the universe.§ The peculiar efficacy of the "Exclusiva" now becomes apparent. All "natures" save one being excluded by a series of skillful experiments from causal connection with the phenomenon under investigation, the residual element is negatively, but conclusively, proved to be the "true cause" or "form" sought for.

It was from this special invention, and not from the general application of inductive rules, that Bacon's "Organ" derived its peculiar efficacy. This was the new art of discovery likened by him to a pair of compasses, armed with which the least skillful hand might be guided to define a perfect circle. This was the universal nostrum—*the elixir vitæ* of science—which had the one drawback common to all methods professing to transcend nature—that its operation was clogged with an impossible condition. It is easy enough for us, from our present point of view, to see that the method of exclusions was tainted with a logical vice. It implied a *petitio principii;* it presupposed, while promising to impart, universal knowledge. It was not so easy—it was perhaps impossible—for Bacon, for his contemporaries, and even for his immediate successors, to see this. They did not in fact perceive any impossibility in a scheme for tabulating the universe. On the contrary, they looked forward confidently to the time when it should be accomplished. The preparation of a universal history of nature

* "Works," vol. i., p. 394, Spedding's edition.

† Ibid., vol. ii., p. 16.

‡ "Novum Organum," lib. i., p. 121.

§ The sixth division of the Second Book of the "Novum Organum" was to have been entitled "De synopsi omnium naturarum in universo"; but this part of the work was never executed.

was a purpose always present to the minds of the founders of the Royal Society, and some preliminary steps toward its execution were even attempted by them. Bishop Sprat* has left on record the "queries and directions, what things are needful to be observed," composed with this view. Some of these inquiries sound, to our instructed ears, rather comical. We take the following specimens:

Whether diamonds and other precious stones grow again after three or four years, in the same places where they have been digged out?

Whether there be a fountain in Sumatra which runneth pure balsam?

Whether in the island of Sambrero there be found a vegetable with a worm for its root, diminishing more and more, according as the tree groweth in greatness?

What ground there may be for that relation concerning horns taking root and growing about Goa?

Whether there be a tree in Mexico, that yields water, wine, vinegar, oyl, milk, honey, wax, thread, and needles?

The answer to this last query, furnished to them by one of their "merchants of light," was, that "the Cokos tree yields all this and more."

The disproportionate importance attached to this species of information by the revivers of science is curiously illustrated by the fact that the funds of the Royal Society having been exhausted in printing Willughby's "History of Fishes," they were obliged to decline undertaking the publication of Newton's "Principia." Indeed, one of their most ingenious members was as fully convinced as Bacon had been, that the true highway to that knowledge which is power lay in this direction. Of this remarkable person it is now time to give some account.—*Edinburgh Review.*

[*To be continued.*]

NIGHT-SCHOOLS IN NEW YORK AND PARIS.

By ALICE HYNEMAN RHINE.

THE system of night instruction is so widely different in Europe and America that the following statistics are given with a view to show which of the two methods, as represented by the schools of New York and Paris, has been most successful and of most practical utility to its students.

At the present time there are in the city of New York thirty-two free evening schools. *Thirty-one* of these are primaries or intermediates for *children;* the remaining one is the evening high school, which

* "The History of the Royal Society of London," 1667, p. 158.

is for adults, as a certain degree of proficiency in various studies must be attained for applicants to gain admission.

The students in these schools represent almost every branch of industry in the city. Yet at the commencement of the term of 1879 *two weeks* were devoted by teachers to an examination of the *moral fitness* of applicants for admission—more strictness, the reports tell us, being observed than formerly as to the character of admitted pupils. In consequence, as many were rejected as unqualified as were permitted to attend.

No difference is made in New York in the *system per se* which governs the day and night schools. Some slight changes, however, mark the manner in which it is worked.

The hours of attendance in the night-schools are limited to two. The opening and closing formalities, which are distinguishing features of the day-schools, are omitted. And in the evening high school, although sixteen different books are on the list of studies, choice of subjects is voluntary with pupils. Two classes are instructed each evening by each teacher—the first from seven to eight o'clock, the second from eight to nine. Students are required to be present only when their classes are in session.

With such apparent liberty in the high school in regard to time and choice of subject for study, it has surprised those having charge that the attendance during the second month of the course for 1879 diminished from fifteen to twenty per cent. Remarking upon this unprecedented falling off, the principal of the school says that "there are few of those admitted who do not begin their work zealously, and I doubt not with strong determination to continue during the whole term." But this enthusiasm soon cooled off, and after a few weeks the students who had commenced study so earnestly deserted the schools. This high percentage of absenteeism, however, was principally confined to the younger scholars, adults availing themselves to a greater degree of the educational advantages offered.

In the primary and intermediate schools the number of children who were enrolled as applicants for admission into the evening classes during the past year was 10,269. All of these were under sixteen years of age. The absenteeism among them amounted to sixty-one per cent. of all whose names were placed upon the school registry. Vigorous measures have been suggested to check what is called by the Board of Managers "this deplorable decrease in the attendance of children." Principal among these has been a proposal to enact a truant law, to be enforced during the evening hours. If such a formula were passed, it would be as unavailing as King Canute's edict to the waves. Natural law would prevent its being obeyed.

Of the children who did attend the evening schools the assistant superintendent makes the following remarks in his last report: "Hundreds of young children attend these schools after the labors of the

day have ended, being required to do so either by parents or employers; and, as they enter the class-rooms fatigued by such labors, unless the teachers can attract, interest, and instruct them, they will either become drowsy or resort to mischievous acts to keep awake."

This simple record is in itself a pathetic protest against a system of children's night-schools. If mere book-learning was all that its most earnest champions advocate, it would still be purchased too dearly by forcing growing girls and boys into crowded schoolrooms at night after a day of toil in factories, workshops, or crowded bazaars.

Taking Paris as a representative of European methods, we find that no such absurdity is committed there as the establishment of night-schools for children. The name of these institutions implies their mission. They are called "*cours d'adultes*," and are intended solely for pupils over sixteen years of age.

Their method of instruction contrasts with that of New York, by being in its character not only scholastic and commercial, but artistic, and to a constantly growing extent industrial, technical schools for mechanic arts being a marked feature of night instruction.

Choice of subjects in the *cours d'adultes* is entirely optional with pupils. And, as more circumstances are likely to arise preventing night attendance than day, the night-schools of France are perfectly free to all who desire entrance—even the formality of registering names not being required from applicants seeking admission.

All tuition at night in Paris is given in the form of lectures by competent professors. These lectures, embracing all subjects of study, are made both instructive and attractive by illustrations and experiments whenever possible. It is found that students learn more from these popular lectures than during hours of wearisome study. They also make familiar the technical names of things relating to different pursuits, and thus enable the multitude to read intelligently such books as treat in a scientific manner of the higher branches of their avocations. By making knowledge pleasurable, the schools of Paris, in marked contrast to those of New York, are crowded nightly by audiences desirous to learn.

Another special feature in night education in France, which would bear transplanting to America, is the *school library*. In 1877 there were 7,764 of these civilizers of men in France; the number has grown proportionately greater since then—five hundred new libraries having been instituted the past year of 1879. These libraries are either in the schools or school-wards, sufficiently near to be used for purposes of reference. The state has set aside a yearly sum of 120,000 francs for the purchase of books. Thus these libraries acquire a constantly increasing size and value.

Many of these free libraries, however, are not due to the state, but to the liberality of private individuals, who make strenuous efforts for their institution in localities where needed. All of these are accessible

to others than pupils—in fact, to all who wish to use them, parents as well as children—and are open for reading *fourteen hours* out of every *twenty-four*.

For this system of scholastic and industrial schools, as well as the school libraries, the total expenditure of the French Government for the whole of France was about *fourteen million dollars* for the past school year. The number of students this sum paid for educating has been estimated at 4,700,000.

Educational appropriations reach a much larger sum than this in the United States, proportion of population considered. New York alone has spent for educational purposes for the past eight years from ten to eleven millions annually. In 1876 eleven and a half millions was disbursed; this was the largest sum ever paid out by the State. Since then the expenditures have somewhat decreased, the returns for the past year showing a smaller sum than any previous year since 1871. The total, however, reached considerably over ten millions. The number of pupils this sum educated (?) was 1,030,000. From these statistics it may be seen that New York pays more than three times as much per head for giving a merely scholastic and commercial education as it costs France to combine these with the artistic and industrial features, including a system of free-school libraries.

If this large outlay of money gave New York in return a more law-abiding, cultured, and self-helpful population, it would be capital well expended. That it does not do this is to be seen in the yearly increase in the appropriations for prisons, reformatories, and charitable institutions of all kinds. In fifteen years taxation has been more than doubled in the State of New York for purposes of public charity. Much of this evil may be laid to the fact that the industrial schools of the great capitals of Europe furnish New York with her best artisans. To remedy this, private enterprise and liberality have founded several industrial schools in New York. Statistics show these to have been well attended. Indeed, the applications for admission have in all cases been far in excess of the accommodations supplied. These night-schools, five in number, are mostly modeled upon the plans of the industrial schools of Paris and Berlin, and of South Kensington, London.

SKETCH OF JOSEPH LEIDY.

By EDWARD J. NOLAN.

IN 1849, Dr. Harvey, the author of the "Phycologia Britannica," describing his visit to the University of Pennsylvania, remarked, "There I met several persons, among whom was Dr. Leidy, a young man who will be famous if he lives and goes ahead according to pres-

ent promises." The promises have been fulfilled. The young man of 1849 has gone ahead, and is now the most distinguished naturalist of America.

JOSEPH LEIDY was born in Philadelphia, September 9, 1823. His father, Philip Leidy, was a native of Montgomery County, Pennsylvania, and his ancestors on both sides were Germans from the valley of the Rhine.

His taste for natural history was exhibited at a very early age, and received judicious encouragement from the master of the school where he acquired the rudiments of an English education. In his leisure moments he, like many other boys of his age, was fond of collecting colored pebbles and curiously shaped leaves long before he had ever heard the words mineralogy and botany. An itinerant lecturer, who described himself as belonging to the "Universal Lyceum," having one day been permitted to deliver a discourse to the school on minerals, his remarks being illustrated by specimens of quartz, mica, feldspar, etc., the boy's interest was so actively engaged that he procured for himself text-books of mineralogy and botany, and began the systematic study of the two branches without any further encouragement or assistance.

At the age of sixteen he left school, with the intention of becoming an artist, as his father proposed. It is evident, therefore, that the remarkable talent as a draughtsman, which has been of such service to Dr. Leidy in his scientific work, was apparent at this early age, and it is not improbable that the world in gaining a brilliant naturalist has lost a distinguished artist. In the mean time, however, much of his leisure had been passed in a wholesale drug-store near his home. His time here was so well spent that the proprietor did not hesitate, when an opportunity offered, to recommend him as competent to take temporary charge of a retail drug-store belonging to a customer. He was encouraged, by his success in filling the trust thus reposed in him, to study the properties and art of compounding drugs as a profession.

His study of nature while thus occupied had not been neglected. To botany and mineralogy he had added comparative anatomy, his first practical studies in that branch having been made on an ancient barn-door fowl and a common earthworm. So absorbed did he become in his anatomical studies, that at the suggestion of his mother, and with the consent of his father, he gave up all intention of becoming either artist or apothecary, and resolved to devote himself to that profession which would afford him the best opportunity of pursuing those studies from which it was now evident he could not easily withdraw himself.

In the autumn of 1840, therefore, he began the study of medicine, devoting his first year to practical anatomy. Having entered the office of Dr. Paul B. Goddard, he attended three full courses of lectures in the University of Pennsylvania, presented a thesis on "The Com-

parative Anatomy of the Eye of Vertebrated Animals," and graduated as Doctor of Medicine in the spring of 1844.

Immediately after receiving his degree, his first work in connection with the university was as assistant in the chemical laboratories of Drs. Hare and James B. Rogers. He began the practice of medicine in the fall of 1844, and continued it for two years, when he resolved to devote himself wholly to teaching. This course he has never had occasion to regret. His qualifications, natural and acquired, would undoubtedly have secured for him brilliant success as a practitioner, but his work as student and teacher has brought him not only satisfactory pecuniary reward, but also other things to which he attaches far more importance—peace of mind, sufficient leisure to pursue his favorite studies, and freedom from the toils and responsibilities which attend the daily life of the practicing physician.

In the winter of 1844, in addition to his work in the laboratory of Dr. Rogers, he assisted Dr. Goddard, who was then Demonstrator of Anatomy in the university. While yet a student he had attracted the attention of Dr. Horner, the Professor of Anatomy, by his success in making a beautiful preparation of the ducts of the lachrymal glands, and this interest was sufficient to secure his appointment as Prosector to the chair of Anatomy in the winter of 1845.

In the year 1846 Dr. Leidy was elected Demonstrator of Anatomy in the Franklin Medical College. He held this position, however, only during the first session, and the next spring again associated himself with Dr. Horner, and gave a private course of anatomical lectures to his students and others.

In the spring of 1848 he accompanied Dr. Horner to Europe, and enjoyed, for the first time, a long-desired opportunity of examining the museums and hospitals of England, Germany, and France.

On his return he gave a course of lectures on microscopic anatomy, and in the spring of 1849 began a course on physiology in the Medical Institute, but owing to ill health, induced by incessant labor, he was obliged to take a rest extending over several months.

In the spring of 1850 Dr. George B. Wood was transferred from the chair of Materia Medica to that of Practice of Medicine in the University of Pennsylvania. Desiring to form an illustrative collection of specimens, models, and drawings, he was accompanied to Europe by Dr. Leidy, whose services in the selection of the material required will be evident to those who visit the museum of the university.

In the winter of 1852 Dr. Horner, who had been in ill health for some time, was unable to continue his course. With the consent of the Board of Trustees, he appointed Dr. Leidy as his substitute, and so acceptable to faculty, trustees, and students were the lectures delivered in completion of the course, that, on the death of Dr. Horner, Dr. Leidy was elected Professor of Anatomy in the spring of 1853.

During the war he was surgeon to Satterlee Military Hospital. His

special duty was to report on the more important *post-mortem* examinations made, and several of these reports, with beautiful illustrative drawings, are published in the "Medical and Surgical History of the War."

In 1871 he was appointed Professor of Natural History in Swarthmore College, a position which his natural aptitude for imparting scientific information makes pleasant to him.

Apart from the record of his intellectual activity there is but little more to be stated regarding Dr. Leidy, for we are of the opinion that in an article of this kind a eulogium would be out of place, although in the present instance there is every temptation to write a warm one. Since his election to his professorship in the University of Pennsylvania, Dr. Leidy's life has been the placid one of the student. At the earliest possible moment he had resolved to depend wholly on his own efforts for a livelihood. The struggle had been severe, the work incessant, and the success achieved at the early age of thirty years was due, not at all to social or family influence, but solely to personal merit. Since 1853 his published works have been his "footprints on the sands of time," and it only remains to allude briefly to the more important of these, and to his connection with an institution which in no small degree has been instrumental in enabling him to secure his present enviable position in the scientific world.

In 1844 Dr. Amos Binney, who then contemplated the publication of his superb work on the terrestrial air-breathing mollusks of the United States, was desirous of employing an anatomist who was also an artist, to dissect and draw the internal organs of the species to be described. On the recommendation of Dr. Goddard, Dr. Leidy was selected to take charge of the work. The result was the production of sixteen plates, giving the anatomy of thirty-eight species of native mollusks with a beauty of finish and accuracy of detail which have never been excelled. Dr. Leidy afterward wrote the chapter of the introduction entitled "Special Anatomy of the Terrestrial Mollusks of the United States."

Dr. Binney's intention, after the work had progressed sufficiently to demonstrate the ability of the artist to render much higher service than that of a mere draughtsman, was that Dr. Leidy should give a complete anatomical and physiological description of the terrestrial gasteropoda of the United States, including the special and general anatomy, with the embryology of the several genera. Before the special anatomy was completed, however, the death of Dr. Binney put a stop to the work. Referring to Dr. Leidy's dissections and drawings, Dr. Binney very justly remarks in his preface, "They constitute the most novel and important accession to science contained in the work, and are an honorable evidence of a skill and industry which entitle him to a high rank among philosophical zoölogists."

Dr. Leidy's studies of the terrestrial gasteropods excited the atten-

tion of the leading naturalists of Philadelphia, and quickly brought him into communication with Cassin, Morton, Phillips, Bridges, Gliddon, Gambel, Conrad, Vaux, Pickering, and other leading members of the Academy of Natural Sciences. Community of interests led to an intimate association with those gentlemen, and he was elected a member of the Academy in July, 1845.

His first published communication, entitled "Notes on White Pond, Warren County, New Jersey," was presented to the Academy in October of the same year, and so active from that time was his work in connection with the society that, at the annual election, in 1846, he was elected chairman of the Curators, a position which he has since uninterruptedly occupied. With characteristic modesty he has frequently declined the presidency of the society, and has contented himself with the quiet, unostentatious performance of the very important duties of chairman of the Curators. The respect and personal affection with which Dr. Leidy inspires every one brought into intimate communication with him, together with his practical good sense and knowledge of the needs of a large collection of objects of natural history, have enabled him to act with great efficiency in his office for the good of every department and interest of the society. He has been also a number of years chairman of the Library and Publication Committees.

Shortly after assuming his position in the university, Dr. Leidy edited an edition of Sharpey and Quain's "Anatomy," with a view to supplying the wants of his class while preparing a manual of his own. The latter was published in 1861, and for clearness and accuracy of statement and convenience of arrangement has not been equaled by any other elementary treatise on human anatomy in the English language.

Dr. Leidy's earlier scientific work was confined to no specialty. The whole field of Nature lay extended before him, and innumerable were the objects of interest which engaged his attention. Hence one is surprised to find how almost encyclopedic is Dr. Leidy's knowledge of natural history. Although he has published little or nothing upon either mineralogy or botany, his knowledge of both these sciences is rather that of one who devotes himself specially to them than that of the casual student. The pages of the "Proceedings" of the Academy for 1845 and 1846, however, indicate that his favorite field of research during that time was among the lower animal forms, and that his microscope was often brought into use. The anatomy of spectrum femoratum (Say), new species of entozoa, the mechanism which closes the wings of grasshoppers, the situation of the olfactory sense in the gasteropods, and new species of planarian worms, were among the subjects upon which communications were published in rapid succession during the first two years of his connection with the Academy.

In October, 1846, he recorded the occurrence of a species of trichina in the hog, and stated that he could perceive no distinction between

it and *Trichina spiralis* which he had met with in several human subjects in the dissecting-room, since attention had been directed to it by Mr. Hilton and Professor Owen. Leuckart afterward acknowledged that he was indebted to this communication for his success in tracing the development of trichina in the hog and man.

In September, 1847, he published his first paleontological paper, entitled "On the Fossil Horse of America," in the "Proceedings" of the Academy. The existence of remains of extinct horses on the American Continent had been regarded with incredulity, in consequence of the entire disappearance of these animals in after-ages. The paper consists of descriptions and figures of specimens contained in the Museum of the Academy of Natural Sciences of Philadelphia, some of which the author regarded as belonging to the South American form, described by Owen under the name *Equus curvidens*, and others as indicating a new species, for which he proposed the name *Equus Americanus*.

His investigations on the development of cartilage-cells, the structure of the liver, of the nettling organs in hydra, the presence of the first indication of muscular fiber in the gregarines, the discovery of the eye in the perfect condition of the cirrhopoda, together with descriptions of many new forms of entozoa and entophita, miscellaneous anatomical and zoölogical notes, and a continuous series of papers entitled "Helminthological Contributions," enriched the pages of the "Proceedings" of the Academy during the next four or five years. His elaborate memoir on the "Anatomy of Corydalus Cornutus in its Three Stages of Existence," published in the "Memoirs of the American Academy of Arts and Sciences," and his beautifully illustrated monograph entitled "A Flora and Fauna within Living Animals," issued as part of the fifth volume of the Smithsonian contributions to knowledge, merit special mention.

These communications, laboriously prepared as many of them were, did not, however, indicate the full extent of Dr. Leidy's industry. Since the publication of his paper on the fossil horses of America, much of his time had been occupied in the study of the vertebrate fossils in the museum of the Academy, or which were brought to his notice from time to time by collectors. Long before the active exploration of the West had added so immensely to our knowledge of the extinct fauna of that region, he had determined the former existence, in a tropical climate on our western slope, of the lion, the tiger, the camel, the horse, the rhinoceros, and many other forms having no immediate existing representatives.

In 1853 the Smithsonian Institution published his memoir on the extinct species of American ox, and in the following year the elaborate "Ancient Fauna of Nebraska." Other paleontological papers were published in the "Transactions of the American Philosophical Society," and many new genera and species were announced in the "Pro-

ceedings" of the Academy. The extent to which Dr. Leidy was absorbed in his paleontological studies, between the years 1854 and 1872, may be judged by the fact that, out of seventy-two communications published during that period, only thirteen were on the subjects to which he had formerly devoted his attention, and these were, for the most part, brief reports of verbal communications made before the meetings of the Academy.

In 1869 his memoir entitled "The Extinct Mammalian Fauna of Dakota and Nebraska" appeared as the seventh volume of the journal of the Academy. The work, a quarto of 472 pages, illustrated by thirty lithographic plates, is the result of the gradual accumulation of material during twenty-three years. This elaborate work was followed in 1873 by one of equal importance, under the title "Contributions to the Extinct Vertebrate Fauna of the Western Territories." It forms the first volume of the superb quarto reports of the survey of the Territories, under Dr. Hayden, and consists of 354 pages and thirty-seven plates.

For many years after the publication of his paper on fossil horses, in 1847, Dr. Leidy was almost the only American author whose attention was given to the study of the extinct vertebrata. The wonderful remains brought to light by the explorations under the direction of Dr. Hayden had, however, excited the interest of others, and private expeditions, as well as the official surveys, had collected rich stores of vertebrate fossils, in some cases from the same localities whence came the material submitted to Dr. Leidy's examination. The anxiety to obtain early publication of descriptions of supposed new forms became so great that, in at least one instance, such description was telegraphed to a learned society from the field. The dispatch was published with as little delay as possible, but the paragraph contained so many errors that the experiment has not, we believe, been repeated. In the attempt to settle questions of priority, the published arguments became so bitter and the personalities indulged in so pronounced that Dr. Leidy, who had been able to refrain from taking part in the controversy, finally withdrew from the field. With characteristic amiability, he had remarked in the preface to his last-named work: "The investigations and descriptions of some fossils from the same localities have been so nearly contemporary with my own that, for want of the opportunity of comparison of specimens, we have no doubt in some cases described the same things under different names, and thus produced some confusion which can only be corrected in future." And, while others were making anxious inquiries regarding dates of issue, and personal bulletins were followed rapidly by bitter little notes of reclamation, he placidly held to the belief that the future would undoubtedly award the credit where it belonged, and withdrew to resume the studies which he had prosecuted so successfully in former years. The only paleontological communication of importance which

he has since published is his "Description of Vertebrate Remains, chiefly from the Phosphate Beds of South Carolina," in the eighth volume of the journal of the Academy.

Finding that the activity and enthusiasm of the younger naturalists, who had taken up the study of the extinct fauna of the West, were quite sufficient to guarantee the prompt use of the fine collections which still continue to be received from that region, and constitutionally indisposed to take part in the battle for priority, Dr. Leidy availed himself with pleasure of the opportunity to study a group of minute organisms to which he had already given some attention. For the next four years he devoted all his spare time to collecting, studying, and delineating the fresh-water rhizopods of America, and the results of his work are embodied in the twelfth volume of the report of the United States Geological Survey of the Territories. The memoir is entitled "Fresh-water Rhizopods of North America," and is perhaps the best illustration of Dr. Leidy's qualities as a naturalist, and the most enduring monument to his industry, which has yet appeared. While preparing the work he spent the greater portion of two seasons in the West, under the auspices of the Survey, and made careful explorations of the country about Fort Bridger, the Uintah Mountains, and the Salt Lake Basin, in search of materials for the memoir.

Since the issue of this superb monograph, Dr. Leidy has been engaged in preparing a new edition of his manual of human anatomy. When this is finished, he intends collecting material for an elaborate illustrated work on parasites. He will probably publish, in the next number of the journal of the Academy, a paper on the parasites of the white ant, many curious forms of which were brought to his notice during his studies of the rhizopods.

The value of Dr. Leidy's scientific work has lately been substantially recognized by the Council of the Boston Society of Natural History, which awarded him the Walker Prize. On account of the extraordinary merit of his researches, the prize, which usually consists of the sum of $500, was on the occasion increased to $1,000.

In the performance of the great scientific work thus imperfectly recorded, Dr. Leidy has confined himself to the duty of accurately describing what he has seen. He very rarely draws inferences from his accumulated facts, and his innate truthfulness is such as to deter him from theorizing. As a lecturer he rarely indulges in figures of speech or flights of fancy. He is deliberate and lucid in his statements, some of his word-pictures being so nearly perfect as to make the fine blackboard drawings with which he often illustrates his remarks almost unnecessary. His delight at acquiring knowledge of a new fact is only equaled by his pleasure in communicating it to others.

CORRESPONDENCE.

A CORRECTION.

Messrs. Editors.

IN an article published in the July number of your magazine, I said, in speaking of the red-bellied nuthatch, "The author of 'Land and Game Birds of New England' notes that a nest was found in Roxbury in 1866."

This reference should have been to the "Birds of New England," by Samuels.

I can not comprehend how I made this error, for my notes from which I wrote referred distinctly to Samuels's work.

To-day I have learned that Mr. Samuels was wrong in stating that the nest he referred to was found in Roxbury, as it was taken in the Adirondacks by Mr. Minot, a brother of the author of "Land and Game Birds of New England."

I might add that by typographical errors the scientific names of the Loggerhead and Great Northern Shrikes were slightly changed: the former should have been *Collurio ludovicianus*, and the latter, *C. borealis*.

Respectfully yours,
HARRY MERRILL.

BANGOR, MAINE, *July* 7, 1880.

ANIMALS AND THE FACULTY OF DIRECTION.

Messrs. Editors.

I HAVE read Dr. Oswald's "Zoölogical Enigma" in the July number with great interest. One step toward determining by what means animals accomplish such feats must be to find what animals possess the power. The following, which came under my own observation, shows that it exists in the hog:

Some six years since, in one of the New England States, a pig five weeks old was carried in a close box about four miles. The route was very circuitous, with several sharp turns, and the pig was removed from the box to the sty after dark. The following day, near noon, he disappeared, and about three hours later was found at his former home. Curiosity led to the examination of the route taken by the pig, and his tracks could be followed nearly all the way. He had started on a straight line for the place from which he was brought the day before, and had followed that line. At one point an impassable fence turned him from the course, but he had moved along the fence on one side until he found an opening, and then had retraced his steps on the other back to the original line!

LA ROY F. GRIFFIN.

LAKE FOREST, ILLINOIS, *June* 25, 1880.

ABNORMAL ACTION OF OLFACTORY NERVES.

Messrs. Editors.

AN old acquaintance relates that for several months past his nerves of smell have been singularly and strangely acted upon. For instance, in early spring the air would seem loaded with the odors of fresh, ripe strawberries; at other times of peaches and other fruits—the odors were distinct and pungent, while the season and circumstances precluded the possibility of any such fruits being in the vicinity. At other times offensive odors (occasionally very offensive) would seem to indicate the immediate presence of well-known offensive substances, where it was known they were not present. Sometimes, however, odors either pleasant or unpleasant would seem to pervade the air which were unrecognized or new.

In all these cases locality was entirely disconnected with the odor; as, although the subject often changed his locality, to the extent of miles, it produced no diminution of odor. These attacks continue from hours to days.

If we assume the *undulatory theory* in the sense of smell, and that particles from all odorous substances, each through their own peculiar vibration or motion, impinge upon the nerves of the nasal cavity, and thus from the peculiarity of movement rather than of substance produce the sense of smell, may we not assume that the nerve is thrown into a peculiar *condition*, by the motion of the odorous particle, and this condition, repeated through the nerve to the brain, produces the idea of that peculiar smell? Again, may not diseased or unnatural action of itself, or through the aid of other agents, set up *conditions* usually and naturally obtained from what we term odorous substances, and thus induce false reports and ideas? Diseased action alone, or in connection with other than the natural substance, might produce the peculiar condition.

Have we not a like exhibition of perverted function in the nerves of taste under the action of disease? As also to the

nerves of feeling in the sensations of heat and cold, in agues, chills, etc.? And may not this same *condition* of the optic nerves explain the various enigmas of optical illusions? Indeed, may not the nerves of each and all of our senses be subject to abnormal conditions, and thus become unreliable?

These queries, affirmatively answered, would enable us, in the mass of contradictory testimony of different individuals as to *facts*, to transfer the charge of much moral to physical obliquity.

A. L. CHILD.

PLATTSMOUTH, NEBRASKA, *August* 5, 1880.

EDITOR'S TABLE.

THE AMERICAN SCIENTIFIC ASSOCIATION.

THE American Association for the Advancement of Science will hold its twenty-ninth annual meeting in Boston, commencing Wednesday, August 25th, and continuing perhaps a week. It is expected that this will be the largest and probably the most important scientific gathering yet held in this country; and ample arrangements have been made, by a large and efficient local committee, both for the business accommodation of the body in all its departments and for the convenience and pleasant entertainment of the members and guests who may be present.

The purpose for which this Association was established is very well known, but to strangers, who propose attending it, it may be well to say that it is devoted to original researches, which are generally of interest to those only who have paid some attention to special scientific branches. Neither the papers read nor the discussions that follow them are usually of a popular character. They are necessarily dry and unintelligible to those unfamiliar with the subjects; but, to those who have some preparation in science, even though it be of a general sort, there is much in the proceedings of this society that will be found very instructive. It is broken up into a large number of sections, each devoted to a division of science, such as astronomy, physics, chemistry, zoölogy, botany, physiology, geology, anthropology, etc., and programmes are published every morning giving lists of the papers to be read during the day in each section. Though technical, and addressed to specialists, these papers represent the advances in each branch of inquiry, and the proceedings of the successive meetings may be looked upon as comprehensive reports of the annual progress of scientific research.

Any person may become a member of the Association upon recommendation in writing by two members, and subsequent election by a majority of the session. The initiation fee is five dollars, and the subsequent annual dues three dollars; and these payments entitle each member to receive the annual volume of proceedings. New members are usually elected daily during the meeting, but many apply earlier to the permanent Secretary, Mr. F. W. Putnam, Cambridge, Massachusetts. More than two hundred members had been proposed for the Boston meeting a month before it begins.

The sessions of the Association will be held in the Massachusetts Institute of Technology. The address of the retiring President, Professor George F. Barker, of Philadelphia, will be given on the first day, and the new President-elect, Dr. Lewis H. Morgan, of Rochester, will be the presiding officer of the Boston meeting.

SEWAGE IN COLLEGE EDUCATION.

AT the College of New Jersey, in Princeton, a considerable number of students were recently attacked by a malignant fever, of which several of them died. It turned out that the cause

of this fatal outbreak was not the unhealthfulness of the place, but bad sewage arrangements in the college buildings, where the unfortunate students resided.

There was, of course, nothing new or unusual in such an occurrence. There have been thousands of cases like it before. Indeed, as we go back in the centuries we read of great fever-plagues carrying off millions of people, and which were caused by air-poison and water-poison engendered in the filth of human habitations, when the methods and the virtues of sewage and drainage were unknown.

And yet there was something unexpected and startling about this affair at Princeton. The sickness and death that occurred there were not from want of knowledge. The calamity was entirely preventable. It could not be charged to the mysterious providence of God, as is often so plausibly done when the causes of disease and death are not understood. It took place in a great seat of learning, where young men gather to be educated. The business of the place was to think. But if there was knowledge sufficient to prevent this disaster, and the young men were learning how to use their minds, why did the catastrophe occur? The answer is, these young men *were sacrificed to an educational theory.*

The theory to which the Princeton students were offered up is that college knowledge is not to be of the useful kind that is necessary to save life. Utilitarian knowledge—that which instructs people how to preserve life and maintain health, and deal intelligently with practical affairs—is decried in these institutions as vulgar and unfitted for educational purposes. Knowledge for its vital life-uses is flatly repudiated, and the courses of study are made up with reference to quite other objects. The study of dead languages, which, for general students, is most perfectly freed from all utilitarian taint, is the earliest, the most prolonged, and the most prized of all college studies. The whole pressure goes in this direction. Whatever else is neglected, the Greek and Latin are always insisted upon. The students are told that this will make men and scholars of them, while an acquaintance with modern knowledge, science, and the laws of their own nature is hardly to be ranked as education at all. A knowledge of sewage is not included in the Princeton ideal of scholarship, nor is it exacted by the Princeton curriculum. There was information enough to prevent the calamity that happened there, but nobody had any interest in making use of it. It was dead knowledge in the College of New Jersey. The intellectual interest fostered by the institution impels to other acquisitions. The whole battery of examinations, honors, prizes, is adapted to favor dignified, traditional, and disciplinary studies. The Princeton student is not, first of all, thoroughly instructed in regard to the laws of breathing and the circulation, nor of the brain and its conditions of action and limits of endurance, nor of the nervous system and its perils of exhaustion, nor of the stomach with its dyspeptic dangers, nor of the vital forces of the living system and the laws of their economical exercise, nor of the complex influence of environing conditions over human health, efficiency, and enjoyment. He is not taught these prime essentials of welfare as the most imperative of intellectual requirements, because they are slurred as mere "utilities"; and so he is left to die or sicken from poisonous air, or to undermine his energies and break down his health in any of the numberless ways to which carelessness, ignorance, and unregulated ambition may lead. If he does not die of collegiate sewage, he is turned adrift with his "miserable scrapings of Greek and Latin," to find out by bitter experience that it would have been better if he had devoted more of the precious time of his college years to the study of useful things.

We have spoken of the college at

Princeton because it happens to have furnished us with a text; but these strictures have a wider application, for the vice we are condemning vitiates the college system of the country. There may have been excuse for this in institutions founded long before the claims of modern knowledge had anything like their present urgency; but the later colleges exhibit the same defects. The University of Michigan, for example, is of modern origin, having been established nearly a hundred years later than the College of New Jersey, but its educational spirit is of the same kind. It was organized by State authority, and has been maintained from the beginning by public taxes. It is open to all within the State or out, and, excepting a slight initiation fee, is free to every student. One would think that the circumstances were here favorable for giving precedence to that later, higher, and more perfect knowledge which is vindicated in its beneficent uses, and is equally valuable to all classes. Yet this great institution, with its fourteen hundred students, seems just as much enslaved by vicious traditions as the older schools. Middle-age studies are still in the ascendant, as "three years in Greek required for A. B." sufficiently attests. The sciences are taught there, but the classical course is the one encouraged by the whole weight of the university influence; and, consequently, as statistics show, it is the one pursued by an excessive majority of the students. The theory of education which bore its fatal fruit at Princeton is loudly defended at Ann Arbor. A newspaper comes to us with report of the proceedings of the last commencement, held July 1st. These are grand occasions, when the colleges are sure of public attention. A vast audience gathered at this thirty-sixth annual commencement of the Michigan University, but, in place of the usual speeches by the graduating students, an elaborate address was delivered by the Right Rev. Samuel T. Harris, D. D., Bishop of Michigan. The eloquent speaker did not fail to improve the occasion in the interest of all collegiate traditions. Knowing that they are under indictment by the common sense of the age, he came to their defense with a kind of fanatical desperation. The Bishop said:

> Scarcely less cruel is the introduction of a false utilitarianism into education. In education the usefulness of a study is not to be measured by its availability for the business purposes of later life. In education those things are useful, not which may be employed thereafter for business purposes, but which best develop and train the student's faculties and powers. Until education is completed, no student ought ever to be permitted to study anything simply because he proposes to make money by it. It is not the object of education to learn useful things, but to become able to learn and use them. So I say it is a cruel wrong to the student to permit either the instruments or the spirit of mere money-making to be introduced into his educational life. Permit me to say that this is a great evil of which I am now speaking. In too many cases education is dwarfed and perverted by the tendency to yield to this false utilitarianism. In too many cases allurements of worldliness and mammon are allowed to call our ingenuous youth away from the proper objects of education. In too many cases short roads and by-paths are opened up to tempt them away from the proper work of the college and the university, and so to send them prematurely to schools of professional and technical instruction. The result is, that too often we see half-educated men and unformed men sent forth to plead the cases and heal the diseases and lead the thinking of the age. Let us all protest against this evil tendency. For, unless we succeed in checking it in some way, it will lead to the impoverishment of this generation. Let our schools and our colleges and universities make men first, and then let them make lawyers and physicians and teachers. Ordinarily, so far as education is concerned—and we are confining our discussion to that now—the only path to true completed manhood is through a thorough course of educational training. Latin and Greek and the higher mathematics, rhetoric and logic and mental and moral philosophy, these are the useful studies in education. These are the studies by which such men as Newton and Bacon and Stevenson and Butler

and Gladstone were made. I rejoice to believe that a steadfast adherence to this principle does characterize the counsels of this institution. I rejoice to learn that the number of students who take the full classical and philosophical course is steadily increasing. I rejoice to believe that this fell spirit of utilitarianism is not nourished in this place, and I devoutly hope that the time is speedily coming when no one but those who have taken the bachelor's degree will expect to be admitted to the professional schools of this great university. [illegible]

We take exception to this greatly applauded statement on several accounts. Bishop Harris recommends a course of collegiate study, and rejoices in its popularity at the Michigan University, in which not a single one of the natural sciences is included. He assumes that the scientific progress of three centuries goes for nothing in the higher education; and he admits no improvement upon the mediæval scheme of culture. The most developed form of knowledge, that which has created modern civilization, and opened up a new world of truth to the human mind, he passes by as if it had no existence. He advocates the theory of college education of which Princeton has recently illustrated the practice—the theory to which students are immolated. It is an insult to the intelligence of the age. Any college, supported by forced exactions upon the people, which omits the sciences from its curriculum, is an outrage upon the community; and, if it can not be reformed, deserves to be suppressed as a public nuisance.

Again, we object to the Bishop's disingenuous attempt to bring useful knowledge into reproach by talking of "mammon," "worldliness," and "money-making," in connection with it. It is not true that the advocates of educational reform put the educational claims of modern knowledge on mercenary grounds. Does Bishop Harris need to be reminded that there are other uses of scientific knowledge than sordid uses? Does he need to be told that it subserves the highest ends to which knowledge is applicable? Would students be chargeable with a venal purpose if they neglected their Latin and Greek, and took up the study of sewage to protect themselves from fatal college epidemics? The Bishop reprobates in his address the "false and superficial habit of object-teaching"; but if students should take up college buildings as an object-lesson, and thereby gain some knowledge that might not only be of immediate utility, but have a vital value for them through life, who but an infatuated classicist would accuse them of being animated by low and degrading motives? And supposing they should systematically extend this practice and look into the water-supply of Ann Arbor and the sewage of the town, and then examine the hygienic conditions of the public schools, and afterward proceed to the jail and the poor-house, and get up a series of object-lessons on these also, would they be liable to the imputation of being actuated by motives of mere vulgar and debasing utility? This disparaging assault upon the kinds of knowledge which lead to self-preservation, to the maintenance of health, to the promotion of personal and public welfare, and to an understanding of the laws of the human constitution, the natural laws of society, and the principles on which the surrounding world is ordered, was wholly unworthy of the orator, of the occasion, and the university that he represented.

And we can not refrain from saying that his insinuation about making education subservient to business comes with an ill grace from the Right Reverend Bishop, whose education was a direct preparation for his trade. He says, "Latin and Greek, and the higher mathematics, rhetoric and logic, and mental and moral philosophy, these are the useful studies in education." Undoubtedly! but useful to whom? They are the staple studies of the clerical

profession. They are the acquisitions by which clergymen get a living. Our old colleges were all originally seminaries for training professional divines. The traditional curriculum was shaped for the uses of a vocation. Clergymen have been the heads of the colleges for centuries. Every President of the College of New Jersey, for a hundred and twenty-seven years, from Dickinson to McCosh, has been a professional divine. Greek and Latin, rhetoric and logic, and mental and moral philosophy, which Bishop Harris would palm off upon the Michigan boys as giving the only true education, have been the bread and butter of doctors of divinity ever since divinity became a regular business. Let Bishop Harris confine his pot-boiling curriculum for preachers to the technical schools of the profession, the theological seminaries. It is high time that general education were rescued from this slough of specialism and placed upon loftier grounds.

The Bishop denounces the "fell spirit of utilitarianism"; that is, the vile and pernicious impulse to usefulness. What does he think of the clerical spirit in education, as shown, say, in the history of the English universities? Under clerical domination they have notoriously been the fastnesses of bigotry, intolerance, proscription, and scandalous abuse of trust and power. Their professorships and fellowships and scholarships have been sinecures for men in "holy orders"; and the institutions have been fettered and trammeled by absurd theological tests, which public sentiment in England has been fighting for half a century, and has not even yet been able to extirpate. Those universities were ages ago the professional schools for the education of the clergy, and, under continued priestly headships, they have clung with desperation to the dominant studies of theological culture. And, as for the spirit of greed, the unscrupulous perversion of endowments and the ravenous struggle for profitable places, which have been displayed in the long hierarchical administration of those great schools, have been the disgrace of civilization. It is fit that the representative of this system should do his best to keep modern science out of the curriculum of the University of Michigan!

But it is a vain and futile work. Bishop Harris's vehement protest shows that he recognizes the strength of the new tendencies. The same newspaper that brings the report of his speech contains also the following significant paragraph: "Cornell University seems to have introduced a notable change in commencement orations and essays. Among the number chosen for public presentation this year is a paper by Mr. R. P. Green, on 'The Sewage of Ithaca as a Hydraulic Problem,' and one by Miss M. Hicks on 'Tenement-Houses, a Social Problem in Architecture.' Among the list from which these papers are chosen are several on broader subjects, as 'The Relation of Modern Science to Education,' etc." When such topics as these are earnestly taken up by students, and college studies become a fit preparation for dealing with them, society will then begin to reap the substantial benefits, which have hitherto been but scantily afforded by the higher education.

LITERARY NOTICES.

EARLY MAN IN BRITAIN, AND HIS PLACE IN THE TERTIARY PERIOD. By W. BOYD DAWKINS, F. R. S. New York: Macmillan & Co. Pp. 537. Price, $6.50.

THE subject of primitive man and his history, as obscurely traced by archæological research, has now come to be so extensive that is has become necessary to concentrate research in special directions, as the whole field is too large for any one man to cultivate. Professor Dawkins has, accordingly, taken up the question of "Early Man in Britain," and even in his elaborate volume he is unable to present the discussion in its completeness. In his work on

"Cave-hunting," published in 1874, he has cleared the way for the present inquiry into the conditions of life, the growth in culture, and the relation to history of primeval man in Britain. The present work is copiously illustrated, and its author admits that it has defects due partially to the nature of the subject, but chiefly to the swiftness with which our knowledge of early man is being enlarged by new discoveries. The author has no favorite theory to advocate, and writes with caution in reference to chronology, considering that there is little ground for placing confidence in dates. As to the antiquity of man, he thinks that we have far from settled views upon the subject. The scientific problem now is how far fossil man can be traced back into the Tertiary. There are those who hold that the early indications of the human race go back to the Miocene or Pliocene period, but Professor Dawkins finds no trustworthy indications earlier than the Pleistocene, or most recent geological period. He considers that on biological grounds it was improbable, if not impossible, that man should appear much earlier than the period marked by arrow-heads, flint scrapers, etc., an opinion that he shares with some of the most competent geologists of the present time. The earliest man met with in Britain Professor Dawkins states is the hunter of the old Drift period, who had for contemporaries the grizzly bear, spotted hyena, lion, hippopotamus, rhinoceros, elephant, and most of the animals now existing. England and Ireland were then one, and were united to the continent, and possessed vastly different climatic conditions from the present. This primitive man was spread over a wide range of country, of which Britain was but a small part, and must have previously existed a considerable period of time. His successor was a man of a much higher type, who appears to have been equally widespread, and to have been possessed of much better and more varied tools and considerable artistic ability, as shown by his carvings in bone and ivory. Professor Dawkins regards him as the direct ancestor of the present Esquimau, and points out in support of his position a number of striking resemblances. The Pleistocene period closes with the disappearance of these cave-men, and neolithic civilization opens with the prehistoric farmer and herdsman. At the time of his advent, the British Islands had attained nearly their existing shape, and climatic conditions were closely allied to the present. These men were short, well built, black-haired, and of swarthy complexion. They came wandering westward from the East, with flocks and herds and some knowledge of agriculture. Before them the mild and unwarlike progenitors of the Esquimau fled, leaving but little trace behind them. The conquerors brought with them many of the arts that raise man above the brute, and overrun the greater part of Europe, and a considerable portion of Asia and Africa. They were in turn displaced by the fair-haired Celts, the van of the Aryan migration, who exterminated, moved them aside, or enslaved them. A mixture of the two races occurred over the greater part of Europe, producing the main characteristics of the peoples of modern Europe. To the neolithic period succeeded that of bronze, and this in turn gave place to that of iron, the age which includes our present civilization. With the beginning of the historic period, the work of the archæologist yields to that of the historian, and at this point Professor Dawkins takes leave of his subject.

REPORTS OF THE PEABODY MUSEUM OF AMERICAN ARCHÆOLOGY AND ETHNOLOGY, IN CONNECTION WITH HARVARD UNIVERSITY. Vol. II. 1876–'79. Cambridge: printed by order of the Board of Trustees. 1880. Pp. 775.

THIS goodly volume contains the tenth, eleventh, twelfth, and thirteenth annual reports, and covers the last four years of museum-work. And very able and fruitful has been this work, as directed by the zealous skill of its curator, Professor Putnam, and the craniologist, Mr. Carr, his assistant. This book constitutes a no mean monument of home work done in American archæology. Did space suffice, it would be a pleasant task to review these reports at length. Besides a good deal of matter which merely concerns the shop-work of the institution, we find twenty-two articles all devoted to American archæology and ethnology, and each one containing results of original research. Thus there are papers of first-rate significance under such names as Putnam,

Carr, Abbott, Shaler, Andrews, Bandelier, Schumacher, Blake, Reynolds, and Morgan. As we retrospect American archæology, this volume assumes an interesting prominence. It is only turned a generation of years since that grand venture was made of the first volume of the Smithsonian contributions to publish Squier's and Davis's "Ancient Monuments of the Mississippi Valley." Davis's collection of antiquities, therein so well figured, was to us a sight never to be forgotten. It is about a score of years ago when we groaned in spirit with that worthy man. Misfortune had set upon him, and he must sell his treasure. Must it be said that in the whole breadth of our wealthy land neither individual nor institution could be found to give the poor man a bid? So an Englishman appears, who buys the collection, and removes it to his own country. What a change since then! Not to speak of the national treasures of the Smithsonian in this line, our country has now, through the far-sightedness of one remarkable man, its special museum of American archæology. Of the grand collection it already possesses, and the solid work it is doing, these interesting reports are in evidence.

Of course, we can not specify articles, but perhaps may say that no papers in this volume will command more attention than those of Dr. Abbott, in which he insists on his having found palæolithic implements in undisturbed glacial drift, near Trenton, New Jersey; and his claimed discovery of an interglacial (why not autochthonic?) race of men. Assuredly the Doctor shows much skill in his diagnosis, and his subject receives what the faculty might term heroic treatment. As against very high authority, he insists on a difference of action in the deposition of the gravels in his cliff, and of others in the railroad-cuts near by, albeit both are of the same geological horizon. The Doctor feels that the difference thus claimed favors his theory. Without expressing any opinion, it must be admitted that the position is argued with ability.

It is quite in keeping with the importance of the subject when Professor Putnam induced Professor Shaler to make a geological reconnaissance of the places containing the supposed palæoliths; and it should be said that the conservatism of the Professor's report shows a safe spirit, although it is, on the whole, not unfavorable to Dr. Abbott's views. We own to some surprise that this report does not so much as allude to Dr. Cook's labors. He says: "I hope hereafter to finish a detailed account of the geology of these gravel-beds." He also says: "The entire absence of organic remains in the mass proves that it was essentially a lifeless sea in which they were laid down." It may be of interest to state that, since Professor Shaler wrote his report, the New Jersey State geologist has obtained from the gravel in the railroad-cuts at Trenton a large portion of a proboscidian's tusk, which has suffered indubitable wear from water, and perhaps glacial action.

It is, we think, a fact patent to all who know what is meant by solid, patient work in the domain of science, that this new science of prehistoric archæology has drawn to itself an immense brood of callow thinkers. The merest accident of finding a few relics is supposed to constitute the text and the ability for a paper on the subject, either for some periodical or maybe some learned society. The lookout is good for American archæology in that we have so grand a school as this Peabody Museum, and so safe a vehicle of instruction as is afforded by its annual report. The tread of Science should be stately, and her footing sure. None more than she should "prove all things, and hold fast the good." *Festine lente.* When, in these fascinating walks of grand thinkings, the imagination gets into a rush, it will be well if this institution shall provide the engineer who will whistle down the brakes.

THE TAXIDERMIST'S MANUAL. By Captain THOMAS BROWN, F. L. S. New York: G. P. Putnam's Sons. 1879. Pp. 199. Price, $1.25.

THIS reprint, from the twenty-eighth English edition of Captain Brown's Manual, will be a very welcome book to the large and increasing class of students and amateurs interested in natural history and the preservation of natural-history specimens. The author thinks that many valuable specimens are lost because of the lack of infor-

mation, among naturalists as well as amateurs, regarding the proper means of preserving them. He has, accordingly, given a clear and concise account of the art, the implements used, and the principles upon which the work should be done. The subjects considered are, the skinning, preparing, and mounting of quadrupeds, birds, reptiles, fishes, molluscous animals, etc.; the preservation of spiders, and preparation of skeletons. The choice and manner of collecting animals, recipes for various articles used in the art, and some instructions to travelers, complete the work. A half-dozen well-engraved plates exhibit the manner of mounting, and preparing the animals and tools used.

SPECTRES FUGITIFS OBSERVÉS PRÈS DU LIMB SOLAIRE (Fugitive Spectra observed near the Solar Limb). By M. L. TROUVELOT.

THE author in this pamphlet describes some remarkable phenomena which he has noticed several times in his observations of the solar spectrum. His attention was first called to them on the 30th of August, 1877, when, all at once, the spectrum was crossed, with the quickness of lightning, by extremely brilliant spectra, which succeeded each other rapidly and ran the full length of the spectrum. The phenomenon was observed on the following days to the 3d of September, the fugitive spectra varying in shape and intensity, and appearing at unequal intervals. Some moved across the solar spectrum or parallel to it, others were stationary. The fugitive spectra were next noticed at Creston, Wyoming, during the observations of the eclipse of the sun in July, 1878, and again at different intervals till the 2d of February, 1880, when the last observation described in the memoir took place. They generally came in numbers, not alone, and in spells of several days at a time, separated by intervals sometimes of months. M. Trouvelot does not derive from this any theory as to the frequency with which they may really have manifested themselves; for, though he saw them only fifteen times in thirty months, he was actually observing the sun for only one hundredth of the time during that period, and they may have been active during the other ninety-nine hundredths of the time without his noticing them. He satisfied himself by every possible experiment and form of reasoning that they were not of terrestrial but of cosmical origin. Two theories are proposed to account for them: 1. That they arise from the meteoric bodies that are supposed to be constantly falling into the sun; 2. That they come from the incandescent matter which the sun throws up in the eruptions which have been observed to take place from its surface. M. Trouvelot prefers the latter theory.

PROCEEDINGS OF THE DAVENPORT ACADEMY OF NATURAL SCIENCES, Vol. ii., Part II. July, 1877, to December, 1878. Davenport, Iowa: published by J. D. Putnam, March, 1880.

PERHAPS one may be pardoned for slightly altering the hackneyed citation, by asserting that "westward the star of science takes its way." In this contribution of the Davenport Academy is that of which the elder academy in the East need not be ashamed. We notice, too, this Western academy is appointing its professors after the methods of the Eastern one. In these proceedings we find original work in archæology, botany, entomology, conchology, paleontology, and embryology, and all these illustrated by plates. The most labored and lengthy article is one by J. Duncan Putnam, on the maple-bark scale-insect (*Pulvinaria innumerabilis*). This article is very exhaustive, and of great biological merit. There is a short but interesting paper by Dr. R. J. Farquharson, on the formation of ground-ice in the rapids of the Mississippi. This is a revival of the long-mooted question, How is anchor-ice made? Dr. Farquharson gives the bibliography of the subject. The Doctor's theory in a nutshell is this: that rapidly-flowing water will get so mixed that its temperature becomes uniform throughout, and when at its freezing-point an arrest of motion will favor congelation, so that there is needed "but the slack-water afforded by the eddy of a bowlder, or a pot-hole, to freeze instantly into a spongy mass." We wish this Western academy the prosperity it so well merits. For two things is this Iowa institution notable: that it is indebted for its building-site to a noble-hearted woman, Mrs. P. V. Newcomb; and its president is Mrs. Mary

L. D. Putnam, a lady to whose zeal the prosperity of the academy is largely due. We observe that a good deal of work is done in archæology, which is certainly wise, considering the richness of this Western field.

HEALTH AND HEALTHY HOMES; A GUIDE TO DOMESTIC HYGIENE. By GEORGE WILSON, M. A., M. D. With Notes and Additions by J. G. RICHARDSON, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 307. Price, $1.50.

THIS is an American reprint of the excellent work of Dr. Wilson, accompanied with a brief preface by Dr. Richardson, of Philadelphia, and such notes as the application of Dr. Wilson's statements to American sanitary condition seemed to warrant.

The book is designed to reach and interest all classes of readers, and the various subjects considered are therefore treated in a practical, untechnical manner. Dr. Wilson opens his subject by a consideration of the amount of preventable disease, which he finds to be still very great, though it has been steadily declining, and there is good reason to hope for continued improvement in this direction. Such a description of the structure of the human body and the functions of the various organs is given as will enable the reader to have a clear appreciation of the laws of health, and the causes of diseases are then explained and illustrated. Among these causes are considered heredity, personal habits, mode of living, work and worry, bad air, food and water, etc. The subject of food and diet is treated quite fully, the nutritive value of the various foods, together with a considerable amount of information of the principles of dietetics, being given. Cleanliness, bathing and clothing in relation to health, and the hygienic value of exercise and recreation, as well as the essential features of healthy houses and surroundings, are duly considered. In the closing chapter of the book the principal dangerous infectious diseases are dealt with, and their mode of dissemination, and the precautionary measures necessary indicated.

Though the work is a continuous exposition of the subject of domestic hygiene, each chapter is made complete in itself, so as to be read independently of any other. The variety and extent of the information contained in the small compass of this volume eminently fit it for household use, while the position of the author is a guarantee of the accuracy of its statements.

WATER ANALYSES FOR SANITARY PURPOSES, WITH HINTS FOR THE INTERPRETATION OF THE RESULTS. By E. FRANKLAND, Ph. D., D. C. L., F. R. S. Philadelphia: Presley Blakiston. 1880. Pp. 149. Price, $1.

THIS is an exposition of the most reliable means of making analyses of water by the well-known chemist, Dr. Frankland. The greater part of the book is of purely technical interest, but in the appendix Dr. Frankland has given briefly information regarding the purity and value of different kinds of water that is of concern to the general public.

He finds that the best water for dietetic purposes is that of deep springs and wells, and the worst that of shallow wells, which are usually situated near drains, cesspools, etc. Rain-water, collected at a distance from towns and upon surfaces kept clean, is next in purity to that of deep wells; that collected from roofs and stored in underground tanks is rarely good enough for dietetic purposes. Water from the surface of uncultivated land is fairly good, while that from cultivated land is not sufficiently good for domestic use, though better than shallow well-water. River-water when it is from cultivated land and is polluted by sewage and factory refuse, is always dangerous to use. Surface and river water containing more than 0·2 part of organic carbon or ·03 part of organic nitrogen in 100,000 parts, is to be avoided for domestic use when possible.

Dr. Frankland states that organic matter in solution in water is so very persistent, that sewage would not be completely oxidized and destroyed in traveling from the source to the mouth of any river in the United Kingdom. Impure water can be more or less improved by filtration through sand, spongy iron, and animal charcoal, but even this can not be relied upon to render sewage-tainted water fit for use. Boiling is probably effective in destroying the power of such water to communicate disease. Water suffers little or no deterioration in transmission even through long

mains, if they be properly laid, and organic material, such as hemp, be avoided in making the joints.

HEALTH. By W. H. CORFIELD, M. D., Professor of Hygiene and Public Health at University College, London. New York: D. Appleton & Co. Pp. 361. Price, $1.25.

THE contents of this volume were delivered as a course of lectures at the rooms of the London Society of Arts, under the auspices of the National Health Society. It is an unpretentious but useful statement of the most important principles of personal hygiene, and the precautions necessary for the prevention of disease. Dr. Corfield's reputation as a practical student of this subject sufficiently attests the care and accuracy of his statements; and the style of the book is so plain and simple as to be easy to all readers. In speaking of the health of the individual his statement of the hereditary feature is especially clear. Half a dozen lectures are first given to preliminary physiology, and then "The Air," "Food and Drink," "Drinking-Water," "Houses," and "Communicable Diseases" are treated in the remainder of the course.

THE CHILD'S CATECHISM OF COMMON THINGS. By JOHN D. CHAMPLIN, Jr. New York: Henry Holt & Co. 1879. Pp. 289. Price, 60 cents.

THIS little book gives a large mass of information about common things, arranged in such a manner as to be interesting to and easily consulted by a child. The subjects are classified under the mineral, vegetable, and animal kingdoms, the information under each being given, as the name indicates, in the form of questions and answers. An excellent design, illustrating the inquisitive attitude of the child toward the things around him, appears on the cover.

FREE LAND AND FREE TRADE: THE LESSONS OF THE ENGLISH CORN-LAWS APPLIED TO THE UNITED STATES. By SAMUEL S. COX. New York: G. P. Putnam's Sons. 1880. Pp. 126. Price, $1.25.

THE main purpose of this work is as an argument in favor of the principles expressed in the leading title. The author believes that "we are rapidly outgrowing the market to which our tariff walls practically limit us," and that "we must have the opportunity and privilege, the liberty, to trade," for which we must be free to buy as well as to sell. He sees, also, a great danger of a land monopoly, the first signs of which have appeared in the practices, the freight combinations, and the high rates charged for transportation by the railroads. The corn-laws of England and the land troubles of England and Ireland are discussed as affording historical illustrations of the author's views.

SEA-AIR AND SEA-BATHING. By JOHN H. PACKARD, M. D. Philadelphia: Presley Blakiston. 1880. Pp. 121. Price, 50 cents.

THIS is number eleven of the monographs on hygienic subjects issued under the title of "American Health Primers." Dr. Packard has aimed to give such information concerning the subject, and such practical directions, as will be of use to those seeking recreation at the seaside. Such questions as how long to remain in the water, how to bathe, what care to take against accidents, and what to do in cases of apparent drowning, are among those considered.

RADICAL MECHANICS OF ANIMAL LOCOMOTION. With Remarks on the setting up of Soldiers, Horse and Foot, and on the supplying of Cavalry-Horses. By Colonel WILLIAM PRATT WAINWRIGHT. New York: D. Van Nostrand. Pp. 294. Price, $1.50.

THOUGH the heading of this work is professional, the problems it discusses are both of extreme scientific interest, and of wider application than to the training of soldiers. The writer aims to determine the fundamental mechanical principles of locomotive activity in animals of the vertebrate structure with a view to cultivating those habits of body by which movements shall become most harmonious and efficient. The point of view from which the book has been prepared is well indicated in the opening paragraph. "Many are the expedients which, in the training of soldiers, have been and still are adopted, in order to overcome that fault of body, whatever it may be, which, in ninety-nine men out of every thousand from civilized nations, tends to hinder the man from marching in a straight

line, from discharging his musket without destroying his aim, from cutting perpendicularly with the edge of his saber, and which likewise hinders him from so following in his own frame the motions received from the frame of his horse that the forces enumerated by this latter shall be so absorbed into and discharged with the making of his aim, as to give no recoil from the saddle."

It is thus assumed that some fault in the play of the bony skeleton is the radical cause of the soldier's deficiencies in movement, and this fault is held to be a one-sided action, as is illustrated in right-handedness. The author takes the ground that only a man who is ambidextrous can have the perfect command and full force of the movements of his body. He holds that "the excessive use of one hand, and of the parts of the body brought into action with it, is a cause of general deformity among civilized men. This so interferes with the central-point working of the body as to greatly reduce its power of producing and sustaining action. The working of the spine is the fundamental basis of movement. Motion properly originates in the spine, is directed by the head, and is only followed up by the limbs. The snake presents the simplest type of spinal working." Colonel Wainwright makes a great deal of this last idea, showing that the locomotion of the snake, when mechanically resolved, throws light upon the work of the higher vertebrate machines. The book is curious and attractive.

THE MICROSCOPE IN MEDICINE. By LIONEL S. BEALE, M. B., F. R. S. Fourth edition. With more than 500 Illustrations, most of them drawn on wood by the author. Philadelphia: Presley Blakiston. 1878. Pp. 539. Price, $7.50.

WE have commended the former editions of this work, which now appears much enlarged, and more deserving of the student's favor. We by no means entertain the highest opinion of Dr. Beale as a philosopher; but, as a microscopical observer, and an histological manipulator, his skill and eminence are generally conceded. This elaborate volume, on a rapidly growing branch of physiology and pathology, is entitled to a place among the standard volumes of reference in every well-supplied medical library.

THE FIELD ENGINEER. By WILLIAM FINDLAY SHUNK, C. E. New York: D. Van Nostrand. 1880. Pp. 325. Price, $2.50

IN this hand-book Mr. Shunk has given, in a convenient form, a clear and concise statement of the information needful for the young railroad engineer. The initial chapters give an exposition of the mathematics and methods essential as a basis for work, and following these are instructions as to the use and adjustments of instruments, with hints on field routine. A number of problems of field location occurring in the author's practice are given as covering the greater part of those likely to be met with. Very full tables, a number of which are new, are appended. The book is well printed, in clear type, and bound in leather in the ordinary form of the engineering field-book.

HYGIENIC AND THERAPEUTIC RELATIONS OF HOUSE-PLANTS. By J. M. ANDERS, M. D., Ph. D. Philadelphia: J. B. Lippincott & Co. 1880. Pp. 16.

IN this paper Dr. Anders calls attention to the well-known property of transpiration of plants, and their value on this account as hygienic agents. He has been making some quantitative experiments, and finds that plants having soft, thin leaves, such as the geranium, exhale one and a half ounce (by weight) of watery vapor per square foot of leaf-surface in twelve day-hours during clear weather. In-door plants transpire something more than half as much in the same time as those in the open air. He is, therefore, of the opinion that growing plants are of great value in keeping the air of an apartment properly mois., and can be of considerable help in cases of consumption.

THE FABULOUS GODS DENOUNCED IN THE BIBLE. Translated from Selden's "Syrian Deities." By W. A. HAUSER. Philadelphia: J. B. Lippincott & Co. 1880. Pp. 178. Price, $1.25.

BUT very little has been known by the general public of the mythology of the Jews, while that of the Greeks and Romans is part of the most familiar knowledge. Mr. Hauser thinks that, as Christianity arose among the Jews, a knowledge of the early religious ideas and habits of this people should be of interest to at least the Christian

part of the modern world, and he has, therefore, made this translation from the Latin of Selden's work. This was published more than two hundred years ago, in 1617, and has been out of print nearly as long. A brief sketch of the life of John Selden is prefixed to the volume.

PRACTICAL KERAMICS FOR STUDENTS. By C. A. JANVIER. New York: Henry Holt & Co. 1880. Pp. 258. Price, $2.50.

MR. JANVIER has endeavored to put in as concise and intelligible form as possible such information of the manufacture, classification, and decoration of pottery as will be of interest to the amateur. In the introductory portion he describes the materials used and their properties, supplementing this with a general description of the processes of manufacture. The various wares are fully described, and the errors of many of the names given by shopmen pointed out. The work closes with instructions and practical hints to intending decorators. A list of some of the best works on keramics and full index and glossary are appended. A handsome binding, good clear type, and heavy paper, leave nothing to be desired in the way of book-making.

WE have received from Dr. Eduard Reyer, of Vienna, a pamphlet (in German) on "Tin in Burmah, Siam, and Malacca." The tin district of these countries extends from Bengal down the western coast of Farther India, and through the peninsula of Malacca to the small islands south of it. This region is believed by Dr. Reyer to be the place whence the ancients obtained their Indian tin. Considerable quantities are still produced in Malacca and the islands. The average importation of "Straits tin" into England from 1870 to 1877 was five thousand four hundred tons a year, and the importation to Dutch ports from the islands of Banca and Billitong does not fall far below the same amount. Dr. Reyer also sends us a pamphlet on "Vier Ausflüge in die Eruptivmassen bei Christiania" ("Four Excursions among the Eruptive Masses near Christiania"), in Norway; and "Granit und Schiefer von Schlackenwald" ("The Granite and Slate of Schlackenwald").

SCHILLER'S COMPLETE WORKS, IN ENGLISH. Edited by CHARLES J. HEMPEL, M. D. Philadelphia: J. Kohle. 1879. Pp. 1282.

THIS, the editor states, is the first complete edition of Schiller's works, in English, that has been offered to the American public. It contains all his poetical, critical, philosophical, and historical writings, the only things omitted being Schiller's own translations from foreign languages. The translations are for the most part by well-known literary men, and are of conceded excellence. Careful editorial supervision has been exercised by the editor, Dr. Charles J. Hempel, who also furnishes several of the translations. The work is illustrated with a large number of full-page woodcuts from the drawings of the best German artists, and is printed in clear type on toned paper. It is issued in one and two volumes, and also in parts. The bound volumes are in various styles, at corresponding prices. A sketch of Schiller's life is prefixed to the work. The edition gives an opportunity to possess the writings of one of Germany's greatest literary men, that few of his admirers will allow to pass.

LANDSBERG'S ILLUSTRIRTES WOCHENBLATT (Landsberg's "Illustrated Weekly") is a new German periodical of a size corresponding with that of the other illustrated journals, having sixteen pages and a tinted cover. It bears marks of good editing and the evidence of discrimination in the selection of subjects for articles and illustrations. It is published by Silvius Landsberg, at 17 Centre Street, New York. Price, $5 a year.

"TROMSÖ MUSEUMS AARSHEFTER" is a collection of papers on scientific topics contributed to the Museum Society of Tromsö, Norway. The second part, which has been kindly sent us, contains papers on the "Coleoptera of Tromsö and the Vicinity," by J. Sparre Schneider; the "Marine Fauna of the Northern Coast of Norway," by G. O. Sars; and on "Certain Phenomena of Glacial Action along the Coast," by Karl Pettersen.

PUBLICATIONS RECEIVED.

Calendar of the University of Michigan for 1879–'80. Ann Arbor: Published by the University. Pp. 168.

Catalogue of North American Musci. Arranged by Eugene A. Rau and A. B. Hervey, A. M. Taunton, Mass 1880. Pp. 52. 50 cents.

A Classification for the Natural Sciences. By C. A. Cutter. Pp. 4.

Two Papers on Academic Degrees: 1. On the Regulation and Control of the Degree-conferring Power; and, 2. On the Origin and Significancy of Academic Degrees. By Frederick A. P. Barnard, LL. D., etc. New York. 1880. Pp. 34.

Practical Uses of the Microscope: An Address by R. H. Ward, M. D., President of the American Society of Microscopists. Indianapolis. 1880. Pp. 17.

The Three Climates of Geology. By C. B. Warring, Ph. D. Pp. 36.

Change as a Mental Restorative. By J. Mortimer Granville. London: David Bogue. 1880. Pp. 32.

Ninth Report of the State Entomologist on the Noxious and Beneficial Insects of the State of Illinois. By Cyrus Thomas, Ph. D. Springfield. 1880. Pp. 142.

Sanitary Reform in Japan; A Lecture to the Students of the University of Tokio. By J. A. Ewing, B. Sc., F. R. S. E. Yokohama. 1880. Pp. 18.

The Providence Franklin Society: An Historical Address by the President, W. O. Brown, M. D. Providence. 1880. Pp. 50.

The Influence of Language on Thought. By Professor William D. Wilson, D. D., LL. D., etc., of Cornell University. 1879. Pp. 14.

The Anthracite Coal-Fields of Pennsylvania and their Exhaustion. By Ph. Sheafer, M. E. Read at the Saratoga Meeting of the American Association for the Advancement of Science. 1879. Pp. 10.

Proceedings of the National Microscopical Congress and the American Society of Microscopists, held at Indianapolis, Ind, August 14, 1878. Indianapolis. 1880. Pp. 77.

Transactions of the Medical and Chirurgical Faculty of the State of Maryland, 82d Annual Session. Baltimore. 1880. Pp. 216.

Report made to the New Orleans Auxiliary Sanitary Association on the Construction and Management of Privies. New Orleans. 1880. Pp. 8.

Minutes of the Twenty-fourth and Twenty-fifth Annual Meetings of the State Medical Society of Kentucky. Louisville. 1880. Pp. 27.

Railway Reporter: A Monthly Journal devoted to the Interests of Railway Men. No. 53 Ninth Street, Pittsburgh, Pa. Pp. 20. Subscription price, $1.25 per year.

Advance copy of Vol. VII. of the Survey of the Fortieth Parallel. Being Memoirs of the Peabody Museum of Yale College. Vol. I., Odontornithes: A Monograph on the Extinct Toothed Birds of North America. By Othniel Charles Marsh. New Haven. 1880. 4to, pp. 201, with Thirty-four Plates and Forty Woodcuts.

The Thousand Islands of the River St. Lawrence. Edited by Franklin B. Hough. Syracuse, N. Y.: Davis, Bardeen & Co. 1880. Pp. 307. $1 25.

The Microscopists' Annual for 1879. No. 1. New York Industrial Publication Co. 1880. Pp. 48. 25 cents.

The Book of Ensilage. By John M. Briley. Billerica, Mass.: Published by the author. 1880. Pp. 202.

The Historical Poetry of the Ancient Hebrews. Translated and critically examined. By Michael Heilprin. Vol. II. New York; D. Appleton & Co. 1880. Pp. 213. $2.

A Selection of Spiritual Songs, with Music for the Sunday-School. Selected and arranged by Rev. Charles S. Robinson, D. D. New York: Scribner & Co. 1880. Pp. 192. 50 cents.

First Annual Report of the Department of Statistics and Geology of the State of Indiana. Indianapolis, Ind. 1880. Pp. 514.

An Elementary Text-book of Botany. Translated from the German of Dr. Prantl. Translation revised by S. H. Vines, M. A., F. L. S., with 275 Illustrations. Philadelphia: J. B. Lippincott & Co. 1880. Pp. 332. $2.25.

Claims of a Protestant Episcopal Bishop to Apostolical Succession and Valid Orders disproved, with various Misstatements of Catholic Faith, and Numerous Charges against the Church and Holy See corrected and refuted. By Bishop S. V. Ryan. In Two Parts. Buffalo Catholic Publication Co. 1880. Pp. 277. $1.25.

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POPULAR MISCELLANY.

American Climate and Character.—Mr. C. Edward Young, of Hartford, Connecticut, has given in "The Sanitarian" a summary of the opinions which several distinguished European hygienists have expressed respecting the influence of our climate upon the temperament and civilization of the American people. Dr. Edward Reich, in his "Studien über die Volksseele," speaks of the great difference existing between the English and Americans, although they are of the same race, and ascribes it to the contrast of the climates. The air of America, he says, "is much too dry for the Anglo-Saxon race, in point of heat too excessive; from this results the exaggerated nervous activity, the excesses of the national character, and the mad chase after the material things of the world." Dr. Max von Pettenkofer has concluded, from the investigations he has made into the comparative loss of heat experienced by a person breathing dry air and one breathing damp air, that with the dry air more heat is lost and more created, and in consequence the circulation is quicker and more intense, life is more energetic, and there is no opportunity for the excessive accumulation of fat or flesh, or for the development of a phlegmatically nervous temperament. Hence, in our dry climate is laid the foundation of the nervousness which characterizes our people. Dr. Prosper de Pietro Santa, in his "Essai de Climatologie," makes essentially the same deduction. Dr. Büchner, author of "Mind and Matter," has remarked, in a series of

articles in the "Gartenlaube," that the Americans are tending toward the Indian type, and that he has observed the resemblance not only in the face and form, but also in the gestures and movements. A. Mühry, in his work on "Climatology," says that the evaporation is nearly twice as great at New York as at Whitehaven, England, hence the Americans and English live under very different conditions, and exhibit great divergences of temperament. Dr. Carl Reclam, editor of "Die Gesundheit," compares the air of America and its effects to those of heights, where the lightness and dryness favor extraordinarily the evaporation or exhalation from the body, and notices in the Americans not only the characteristic physical features induced by such an air, but also "mental peculiarities, traces of which may be seen with us (Europeans) by a careful observer during a dry northeast wind." Mr. Young gives as the result of his own observations, that "the dry air with us produces nervous, energetic, large-jointed skeletons, which have little or nothing in common with the stout, fresh, rosy, phlegmatic inhabitants of the mother-country. Not only is the physical resemblance lost in the second generation, but the mental also, and ideas especially Britannic give way to ideas peculiarly American, the product of the climate, the soil, and the habits caused by these two factors." With the English the muscular system predominates; with the Americans, the nervous. American women possess beauty of face, almost never of form; and even the beauty of face is soon worn out by the drying, irritating effects of the climate and of American life. English women have beauty of form and face, and keep both to an advanced age.

The Jablochkoff Electric Light in London.—The London Metropolitan Board of Works has recently renewed a contract for one year for lighting the Victoria Embankment and Waterloo Bridge with the Jablochkoff electric light. The Jablochkoff system has been in successful operation on the Thames Embankment since the 13th of December, 1878, when twenty lights were started between Westminster and Waterloo Bridges. Twenty lights, extending the work to Blackfriars Bridge, were added in May, 1879, and ten more were put on Waterloo Bridge in October last; ten lights have also been placed in the Victoria Railway station. All of the lights on the Embankment have been kept in operation regularly for six hours each night since they were first started—a fact that is worthy of consideration when it is borne in mind that the machinery was originally arranged for twenty lights only, with no thought that the system was to be extended, and that the changes rendered necessary by each of the two extensions have had to be made without interfering with the daily efficiency of the apparatus. The price paid by the Board of Works was, at first, 6*d.* per light per hour; it was reduced to 5*d.* in the first, and 3*d.* on the second extension, and has again been reduced on the renewal of the contract to $2\frac{1}{2}d.$ per light per hour. The Jablochkoff system of electric lighting is now in use under almost every possible condition and in every variety of establishment—in streets, on bridges, in railway-stations, theatres, circuses, engineering and industrial works, docks, basins, on board steam-vessels, in hotels, and in private residences. King Theebaw, of Burmah, has sixty lights fitted up in his palace at Mandalay; the Shah of Persia four, at Teheran; Prince Agaklam six, at Bombay; and the King of Portugal and the ex-Queen of Spain are also using them. At present, seventeen hundred and sixteen are in use in different countries, one hundred and ninety-eight being in England.

Coloring of the Waters in Seas and Lakes.—Geographers were not able to determine why the Red Sea was so named until Ehrenberg, sailing over a part of it, observed that the water of the whole Gulf of Tor was colored a blood-red. Drawing up some of the water and examining it with the microscope, he found that the color was due to a minute, thread-like, dark-red oscillatoria, or alga. The same alga was observed by Dupont twenty years afterward, giving rise to the same appearance over an extent of 256 nautical miles. A similar plant was noticed by Darwin in his voyage round the world, coloring the water near the Abrolhos Islands, off the coast of Brazil. Oersted, in 1845, noticed that the

waters near Madeira had a peculiar obscurity, which was occasioned by numerous minute tufts of oscillatoria waving in the mass. These plants were found all the way to the West Indies, sometimes thick enough to give a color to the water, but never wholly wanting. In other cases the sea is colored red by animals of different kinds, by minute crustaceans or infusoriæ, or eggs. The name of Red Sea or Vermilion Sea has been given to two different phenomena in the Gulf of California, in which the water is colored two distinct shades of red by different microscopic infusoriæ. One of the coloring animals is irritating to the skin, and produces blisters and sores on the bodies of those who come in contact with it. Diatoms often give rise to similar colorings. Professor Cleve, of Upsala, mentions fifty-four species of diatoms which have been found on the surface of the Sea of Java, and speaks of others which have been observed between Europe and Greenland and in Davis Strait. Grunow gives a list of thirteen species which are found near the Nicobar Islands. Kjellmann gives especial attention to the diatomaceous flora in his treatise on the alga of the Kara Sea. The Swedish polar expedition of 1872–'73 saw on the northwestern coast of Spitzbergen an expanse of sea of considerable extent covered with masses of diatoms of a single species, forming what the English sailors call a "sawdust sea." The same has been observed in Davis Strait, in the Kara Sea, and on the northern coast of Finland, covering large spaces. Johann Steenstrup found spots in the Atlantic Ocean between Scotland and Greenland, where the water changes from ultramarine to an emerald green, so suddenly that only a line separates the two colors. The coloring seems to have some relation to temperature, the green prevailing in the warmer months, the blue in the colder, and is thought to be connected with the development of diatoms. Professor Ossian Sars, of Norway, has observed a dull grayish-green color of the sea, which he ascribes to a bathybius that he found floating on the surface of the water. Similar colorings occur in fresh water, and have received the names at times of bloody rains, bloody dews, etc. Schwammerdam, observing water thus strangely colored at Vincennes, was strongly affected by the sight, but, examining it, found that the color was given by small crustaceans. The Musten Lake in Switzerland has been colored by oscillatoria which were so thick in the water as to make it unhealthy for the fish, and to cause them to die; the fishermen are well acquainted with the phenomena, and speak—referring to the mixture of green and red—of the lake blooming. The water in one of the lakes of Denmark has been found colored a deep red by another oscillatoria. In still other cases the colors are given by the spores of an alga. The so-called "bloody rain" is colored by an alga, which, because they have not noticed it before, some believe to have come down from the clouds, while others think it was previously present but was dried up, and has only been refreshed and enlivened by the rain. It has recently been identified with the "red snow," a one-celled, spherical plant, green or red in color, which may be increased by division, and is propagated rapidly in water or melting snow. In the still waters of the coast of Denmark a red deposit appears on the decaying sea-weeds, or floats loosely on the surface, giving a raspberry-red color to the water. It is caused by bacteria, which, probably contributing to the decay of the sea-weed, are thought to have a part in the formation of the sulphuretted hydrogen gas so common in that region. Of a similar character—caused by vegetable or animal growths, often by bacteria—are the colored spots which appear on decaying food; and it can no longer be considered an occasion of marvel that a pond becomes as red as blood, or that what seem to be drops of blood may appear on the sacramental wafers. These phenomena are all assignable to natural causes which have been traced out and are clearly known.

Luminous Paint.—The invention of luminous paint is based upon the fact that certain substances after having been exposed to the light will continue to shine for some time after the light is removed. The existence of this power in some gems has been known for a long time, and is mentioned in some of the works of the ancients. Japanese antiquaries tell of a luminous stone that was dug out of the ground in A. D. 669.

The phosphorescent power of barium sulphide was discovered in 1675. Canton, in 1761, discovered the so-called phosphorus which bears his name by calcining oyster-shells with sulphur so as to form the calcium sulphide, the most remarkable of phosphorescent substances. Its luminosity appears to be permanent, for Professor Heaton, in a lecture describing the qualities of the luminous paint, delivered before the Society of Arts, on the 11th of March last, exhibited a specimen of it which had been sealed in glass by Canton himself in 1764, and which still glowed. The power is attributed to a property which the substances possessing it have of absorbing rays and afterward emitting them with an increased wave-length, as is remarkably shown by quinine, which shines after having been exposed to the ultra-violet part of the spectrum, and converts invisible actinic into visible light-rays. The late Mr. Balmain succeeded in producing from a compound of lime and sulphur a constant and very powerful phosphorescent substance, which he patented and applied as a paint; articles coated with it become luminous after exposure to the light and retain their glow for a considerable length of time. The sensitiveness of this substance was shown during Professor Heaton's lecture by passing electric sparks in front of a card painted with it which had been previously kept in darkness. Each spark impressed its image on the card, and made it luminous. Even a lucifer-match struck in front of a dark pane produced a visible effect on the paint. The highest effect is produced by the violet and ultra-violet rays. The red and yellow rays do not add to the luminosity; in fact, they diminish it when they are allowed to continue to act for a considerable time. This is owing to their calorific effect, which, though it may stimulate the light for a while, in the end causes it to disappear more rapidly. A short exposure of the paint to ordinary daylight is sufficient to produce a high degree of illumination, the amount and duration of which will depend considerably on the quantity and quality of the light and on other conditions. "When the paint has been exposed to the intense light of the sun or of burning magnesium, a good deal of the brilliancy disappears quickly, but after that the fading is very slow; and it may be said that a more or less useful light will remain through the length of an ordinary winter's night. In one case, Professor Heaton was just able to see the dial of a watch by the light emitted from a card which, after having been exposed to daylight of moderate intensity for two hours, had been in total darkness for twenty-six hours. The paint appears to be of satisfactory durability as against all weathers and the action of sea-water. The useful purposes to which it may be applied are almost innumerable. Clock-faces painted with it will show the time; match-boxes can be found, all through the night; the roofs of railway-cars will light passengers through tunnels; buoys in harbors and channels, and life-buoys, can be made visible; ships may show themselves to each other in the darkness; the diver, painting his dress with it, may be his own lantern and carry enough daylight with him to enable him to work under water at a considerable advantage. Its application to use in powder-magazines and coal-mines, and wherever fire-lights are dangerous, may be considered as among the things that are practicable. The manufacturers of the paint, Messrs. Ihlee & Horne, of Aldermanbury, London, say that it now costs twenty-eight shillings, or about seven dollars, a pound, and that a pound of it will paint about twenty-eight square feet. Two years ago they held it at five guineas a pound, but they have been able to lower the price gradually, and hope ultimately that it may be afforded at less than the cost of white-lead.

Is South America rising or sinking?—The question whether the South American Continent is sinking or not is one on which considerable difference of opinion still exists. Professor Orton several years ago expressed the belief that the barometric observations of the heights of the principal mountains, which have been continued through more than a hundred years, afforded evidence of a gradual sinking, and this opinion has prevailed extensively. Professor Agassiz believed that the eastern coast was sinking while the western coast was rising, and Darwin infers, from the discovery of the remains of an ancient civilization on lands that are now too high for the development of human life, that the land is

rising. Dr. W. Weiss read a paper before the Berlin Geographical Society at a recent meeting, in which he advanced the theory, founded on a comparison of observations which had been made at the mouths of rivers, that the continent is rising. The Isthmus of Panama seems to be rising, and signs of elevation are apparent on the north coast of the continent. The delta of the Magdalena River has suffered notable changes within comparatively recent times. The tertiary highland of Turbaco, which extends from Carthagena to Sabanilla, was once an island in front of the stream, as is indicated by the forking of the river. One arm of the river empties toward the west near Carthagena, the other arm forms the present mouth with its branches in the lagoon of Santa Marta; ships formerly sailed into the western arm, which is not now navigable. The closing of this branch is generally ascribed to the luxuriant vegetation, but it is more than probable that other causes were combined with it. A small elevation would be enough to stop the flow of water, and the fact that such an elevation has taken place is shown by the discovery of recent shell-beds in a part of the lagoon. The bay of Santa Marta, with its monotonous sand-flats between steep, bald cliffs and island-like uprising knobs, produces the impression of a recently dried sea-bottom. Similar appearances are presented farther east, to such an extent that it was believed in the sixteenth century that the sea had retreated. The region of the lagoon of Maracaybo, and indeed the whole coast of Venezuela, appears to have taken part in a movement of uprising. The existence of the delta of the Orinoco favors the theory of elevation, for, though it can not be held that deltas are not formed except where the ground is rising, it is nevertheless true that elevation is most favorable to their formation. The observations along the coast of the British, French, and Dutch possessions are contradictory; but as a whole they seem to indicate that the land is gaining on the sea. The character of the changes that are taking place at the mouth of the Amazon is generally supposed to indicate a sinking of the land, but there are circumstances that favor the opposite view. The signs that the upper part of the bed of the river is rising are numerous, and all the phenomena of washing away at the mouth which are generally considered evidences of a depression can be accounted for by supposing that the interior is rising faster than the coast. Indications of a recent elevation may be seen all along the coast from Cape St. Roque to the La Plata, in the hardened shore-ridges of the Rio Grande do Norte, Parahyba, and Pernambuco, the elevated shore-lines of Rio Vermiglio, Bahia, and Rio Jequitinhonha, the coral reefs of the Abrolhos, the holes of the sea-urchin found above the level of the sea near Cape Frio, the new formations near Rio de Janeiro, the deterioration of the harbors of Santa Catarina, Porto Alegre, and other places. Darwin proved by the discovery of recent shell-deposits that the region of the La Plata was rising; since then some facts have been adduced pointing to a sinking, but the La Plata affords relations similar to those which have been referred to in the case of the Amazon. A lake in the Straits of Magellan containing marine animals, but situated at a higher level than that of the sea, is cited by Agassiz in proof that a rise of the land has taken place there. On the west coast signs of a sinking appear in the Chonos Archipelago, but they give way to trustworthy evidences of elevation in southern Chili. These continue to Callao and Lima, where a sinking is suddenly indicated. The land at Callao consists of gravel-beds, which may be considered as river and shore formations. Washings away from beneath, assisted by earthquakes, might readily have caused slight local falls, without making it necessary to invoke a sinking of the land. Not enough is known of the coasts north of Callao to justify a definite expression of opinion.

The Law of Mutual Help.—At the Congress of Russian Naturalists and Physicians, held in January last, Professor K. Kessler delivered an address on the law of mutual help, which he urged was entitled to a place by the side of Darwin's law of the struggle for existence. Having given a brief sketch of the theory of the struggle for existence, Professor Kessler remarked that it did not play the only part in organic development. By the operation of the reproductive instinct, there was developed in the different

animal races a strong inclination for a closer association of the sexes, as well among individuals as in the whole group, under which the members of a society, of the whole species or family to which they belonged, were impelled to assist each other in the struggle for existence. He had observed numerous instances in which, after the death of the male, the female died, and conversely, or parents with the greatest self-denial sacrificed themselves for the protection of their young. All such examples showed that the reproductive instinct bound groups of related animals to each other through the law which he had enunciated. The principle was not limited to sexual association, but was exhibited wherever mutual help appeared to be necessary. As an example, the case was cited of a group of beetles which would combine their forces with severe exertion to drag away a dead mouse. Further, ants and bees illustrate the operation of the law in a high degree. The principle is developed with especial prominence in mankind. Only by the most powerful coöperation could men have succeeded in reaching the degree of civilization which the race has attained.

Iceland.—Mr. C. G. W. Lock, in a recent lecture before the British Society of Arts, on Iceland, mentioned that the island, so far from being small, as it is erroneously called, is considerably larger than Ireland or Ceylon. Its situation is such that its whole northern coast is shut in nearly every year by the descent of masses of ice from the north. The southern and western shores are affected by ice in very exceptional instances only. The country is essentially volcanic and mountainous; but Hecla, which monopolizes the geographical knowledge of most students on the subject, does not possess a single characteristic to place it above its fellows. The whole central plateau is a wild waste of lava and volcanic sand, and the only habitable parts of the island are a narrow fringe of coast-land and a few of the larger river valleys. The great ridge of ice-clad hills, stretching across the island, acts as a refrigerator to the moisture-laden winds from the southwest, and produces two distinct climates: the northern, generally dry; and the southern, generally wet, and more temperate than the other. The fact that colonists from Great Britain participated in the settlement of Iceland more than a thousand years ago is attested by the identity of many words that are used by the people with British words. Ponies are the chief animal product of the island. From them the stocks of the "Black Country" of England are recruited. The sheep furnish a fine mutton, and a wool which is made up into excellent fabrics at home, or is exported. Profitable trades are driven in skins, catgut, fox-fur, and eider-down; the cod-fisheries are very important, and considerable trade is carried on in cod-liver oil and shark-oil. The salmon-fishery has been shamefully abused by the excessive employment of barbarous methods of taking the fish. It, however, is the one great attraction the island offers to sportsmen; and more profit might be gained, directly and indirectly, by letting out the streams, as in Norway, to English fly-fishers, than by contracting with fish-curers. The island was at one time well wooded, and supplied itself largely, if not entirely, with cereals, but the climate has deteriorated and the soil become sterile in consequence of the cutting away of the trees, and every grain of corn is now imported from Denmark. The principal mineral product is sulphur, which is deposited in a very finely divided state around the volcanic vents by the vapors issuing through them. It is the custom to describe the sulphur-mines of Sicily and the sulphur-mines of Iceland as somewhat similar, but for all practical considerations they are as distinct as a coal-seam and a forest. The Sicilian mines consist of deposits formed in past geological ages, now lying at great depths, and utterly devoid of reproductive power; the Icelandic beds are the work of to-day, lie on the very surface of the ground, and live and grow with unabated energy, replacing the deposit as fast as it is removed. The area comprised in the Icelandic sulphur districts collectively amounts to, perhaps, a dozen square miles. The sulphur forms a layer of varying thickness, covered by an earthy crust and underlaid by clays containing sulphur mixed with various acids and salts, and is invariably wet, in consequence of the steam condensed within it. The crystals are almost absolutely pure, but impurities are mechanically mixed with them. Other mineral products

are gold and silver, which are found in minute quantities, Iceland-spar, pure specimens of which are valued for optical instruments and cabinets, coarse chalcedonies and zeolites, lignite, basalt, and volcanic products. The manufacturing industry of the country is confined to woolen fabrics, socks and stockings, gloves, and a home-spun cloth, which are excellent.

The Eyesight of Readers.—A writer in the "Library Journal" calls attention to the danger which readers run of injuring their eyesight by the use of a bad light. He remarks that engravers, watchmakers, and all others who use the eyes constantly in their work, take extra care to preserve them by getting the best possible light by day, and using the best artificial light at night. The great army of readers are careless, and have, sooner or later, to pay the penalty of their carelessness by giving up night-work entirely, and sometimes reading, except at short intervals and under the best conditions. All departures from common type, making the matter more difficult for the eye to take in, increase the danger. The magnitude of the physical labor of reading is not appreciated. A book of five hundred pages, forty lines to the page and fifty letters to the line, contains a million letters, all of which the eye has to take in, identify, and combine each with its neighbor. Yet many readers will go through such a book in a day. The task is one he would shrink from if he should stop to measure it beforehand. The best positions and best lights, clear type, plain inks, with the best paper of yellowish tints, and abundant space between the lines, afford the best safeguards against harm.

What Vivisection has done for Man.—Dr. Charles Richet, in a vigorous defense of the practice of vivisection, demands that it shall be judged by its practical results, and claims that, if it can be shown that we have gained by that method of experiment the means of curing one or two diseases of man or of assuaging pain, it must be considered lawful. He cites a number of discoveries that have been made through vivisection to sustain his position. Among them is the discovery of the circulation of the blood. Galen established the fact that the arteries contained blood by observations in the artery of a living animal; Harvey opened the chests of living animals, cut into the pericardium, observed the contraction of the heart, and what was going on in the veins and arteries, and deduced from what he saw his theory of the circulation. Transfusion of blood, an operation resorted to in extreme cases with the best results in saving life, was introduced after its possibility had been ascertained from experiments upon animals first made in 1664 by Lower and afterward by Denis. "Experiment alone," Dr. Richet says, "will teach us precisely what quantity of blood is necessary and what is harmful; and if over-sensitiveness forbids animal suffering for this end, then the experiments would have to be made on human beings." The mode of death from the inhalation of carbonic oxide, and, correlatively, the method of avoiding or preventing death from inhalation, have been made known only through vivisection. So also "all that we know in hygiene of the quantity of air necessary to support life is the result of experiments on dogs and rabbits. Sometimes a precise knowledge of the conditions of respiration has served to prevent men from perishing." Only two methods exist by which we may learn the conditions of gastric digestion and collect its secretion, viz., by observation of gastric fistulæ produced by chance in man, and by artificial fistulæ in animals. The first method has been possible only in three or four instances, but the effect of food on the gastric secretion in dogs and cats has been largely observed; and the knowledge of the remedies which have been applied to the relief of dyspepsia has been derived from such studies. Our knowledge of nutrition has been largely added to by means of experiments in which dogs and cats have been submitted to varied alimentation, and from which the quantity and quality of food necessary to sustain life have been deduced. What we know of the nerves has been gained from studies of animals, as have also the means of relieving neuralgias and paralysis, in which, thanks to the scientific analyses of the vivisectors Fritsche, Hitzig, and Ferrier, "we can pass from the effect to the cause, and assign to paralysis a central lesion at a well-deter-

mined spot, so that trephining at this spot may cause the paralysis to disappear." The experiments of Galvani and his followers on frogs have taught us to estimate the effect of the electric current on nerve and muscle, and shown us how to apply galvanization to the prevention of the paralysis which ensues from the destruction of the motor nerves. The numerous patients relieved of nervous diseases "by this admirable therapeutic agent have no call to speak ill of such vivisectors as Galvani, Aldini, Volta, Magendie, Marshall Hall, Remak, Du-Bois Reymond, and many others, since it is to their discoveries that the relief of their ills is owing. Would Galvani have made his discoveries had he refrained from dissecting frogs? Would the electric current have been applied to atrophied limbs if it had not been found that the action of this current in dogs was salutary and not dangerous?" Certain diseases of the urinary organs have been studied in animals. The treatment of sympathetic ophthalmia by section of the ciliary nerves of the diseased side has been shown to be advantageous by experiment, and the results yielded by experiments on dogs and rabbits have been applied to patients. The correct treatment of cataract has been similarly learned. Encouraging progress is made by vivisection in the study of the formation of callus, of pseudarthrosis, of osseous grafts, of regeneration of bone by periosteum, subjects of great importance in surgery. The vasomotor theory, which plays a large part in the medicine and surgery of the present day, has been established by experiments on the great sympathetic and the rabbit's ear. Dr. Brown-Séquard has furnished useful ideas relating to epilepsy and tetanus from the results of painful experiments on dogs and Guinea-pigs. Trial on animals is useful to determine the action of new medicines, for "we do not wish to experiment on man at the risk of poisoning him, where animals can be employed"; so with poisons. Finally, if we deprive *savants* of the right to submit living animals to experiment, we shall go back beyond the days of Galen. "If all those who have been relieved—verily made to live again"—says Dr. Richet, "by modern medicine and surgery, could speak, they would confound those who load vivisection with calumny, and they would hold that their own life and sufferings weighed more in the balance than the sufferings of those animals which have been sacrificed in laboratories to the lasting benefit of man."

Compression of the Feet of Chinese Women.—Miss Norwood, an American missionary at Swatow, has published a description of the processes employed to reduce the size of the feet of Chinese women. The binding of the feet is not begun until the child has learned to walk and to do certain other things which she could not well be taught to do afterward. The bandages employed are manufactured for the purpose, and are about two inches wide and two yards long for the first year, five yards long for the subsequent years. The end of the strip is laid on the inside of the foot at the instep, then carried over the top of the toes and under the foot, drawing the four toes with it down upon the sole; thence it is passed over the foot and around the heel; and by this stretch the toes and the heel are drawn together, leaving a bulge on the instep and a deep indentation in the sole under the instep. This course is pursued with successive layers of bandage, until the strip of cloth is all used, and the end is then sewed tightly down. The "indentation" should measure about an inch and a half from the part of the foot that rests on the ground up to the instep. The toes are drawn completely over the sole, and the foot is so squeezed upward that, in walking, only the ball of the great-toe touches the ground. Large quantities of powdered alum are used to prevent ulceration and lessen the offensive odor. At the end of the first month the foot is put into hot water, and, after it has been allowed to soak for some time, the bandage is carefully unwound, "the dead cuticle, of which there is much, being abraded during the process of unbinding." Ulcers and other sores are often found on the foot, and "frequently, too, a large piece of flesh sloughs off the sole, and it sometimes happens that one or two toes drop off." When this happens, the woman considers herself amply repaid for the additional suffering by having smaller and more delicate feet than her neighbors. Each time

the bandage is taken off, the foot is kneaded, to make the joints more flexible, and is then bound up again as quickly as possible with a fresh bandage, which is drawn up more tightly. During the first year the pain is so intense that the sufferer can do nothing, and for about two years the foot aches continually, and has to endure besides a pain like the pricking of sharp needles. If the binding is kept up rigorously, the foot in two years becomes dead and ceases to ache, and the whole leg, from the knee downward, becomes shrunken to be little more than skin and bone. When once formed, the "golden lily," as the Chinese lady calls her delicate little foot, can never recover its original shape; and, when uncovered, it is so unsightly that women object to take off their bandages even before members of their own family.

A Volcano rising from a Lake.—M. de Lesseps has communicated some interesting papers on the extraordinary phenomena which accompanied the earthquakes of January last, in the republic of San Salvador, to which the French journals add accounts furnished by the consul of the republic and the French consul in Guatemala. The shocks, which, although of considerable strength, were not violent enough to do harm to houses, seemed to proceed from a center in the Lake of Ilopango or Cojutepeque. The waters of the lake having fallen from an extraordinary level to which they had risen before the shocks began, a small island with three peaks appeared to be rising from the center of the lake. One of the peaks reached a height of about ninety feet above the water, and sent forth a column of smoke and flames of considerable height. An attempt was made to approach the island in a boat, but the waters in contact with the hot rock were boiling, and gave out great jets of vapor. The water around the volcano continued to boil for some time after the eruption was over, and indicated a temperature of 100° at the edges of the lake. The fish were cooked and rose to the surface, and with them many shells and aquatic animals. The lake is in the line of the volcanoes of Central America, where volcanic cones seem to alternate with lakes, and itself occupies the place of an ancient volcano. Its water is brackish, bitter, and almost slimy, and has at times given out bubbles of sulphuretted gas. The rise of the water preceding the eruption agrees curiously with an ancient tradition that earthquakes may be expected whenever the level of the lake is elevated. So fully was this believed that the people were formerly accustomed to dig channels to carry off the superfluous waters; and while they did this they had no earthquakes. These facts have a bearing upon the theory that earthquakes and volcanic phenomena are largely due to the action of water.

Volcanic Eruptions and Earthquakes in 1879.—According to Herr Fuchs, only three volcanic eruptions took place in 1879, none of which were of extraordinary violence. The most notable one was that coincident with the appearance of a new volcano in Lake Ilopango, in San Salvador, following on a series of earthquakes in December. The eruption of Etna, which began on the 26th of May and lasted for eleven days, was especially marked by an uncommonly long lava-stream—of sixteen kilometres, or ten miles. The preceding earthquakes were not very strong. The third eruption was that of the volcano Merapi, in Java, on the 28th of March, which was marked by an abundance of lava and ashes. Only a few of the ninety-nine earthquakes which came to the knowledge of Herr Fuchs were of remarkable strength. A violent earthquake was felt in northern Persia for several hours on the night of the 22d of March, and destroyed a number of villages. About nine hundred persons perished between that date and the 2d of April, when the last vibrations occurred. Earthquakes of unusual strength occurred in the Romagna (Italy) on the 25th of April, and in Mexico on the 17th of May. In the latter earthquake the movement of the ground was observed in all the region from Vera Cruz to the capital, and much injury was done in Cordoba and Orizaba. Violent earthquakes began in a part of China on the 29th of June, extended over thirty districts, and the shocks were repeated till the middle of August, with the loss of many hundred lives. These earthquakes were marked by great jets of water spouting up through the opened ground.

Several other earthquakes of the year were accompanied by the phenomena of fountains, as in Bessarabia in May, and one on the lower Danube in October. Earthquakes occurred at nine different points in the German Empire on thirteen days. The days on which the most earthquakes were noticed were the 14th of February and the 2d of July.

Relation of the Algæ to the Phanerogams.—Dr. Ernst Krause in a late number of "Kosmos" has a discussion of the relationship between the algæ and the phanerogams, taking the *Podostemaceæ* as the special subject of his dissertation. The species of this family, he believes, combine characteristics of the algæ and phanerogams, and show a direct transition between them, as in the opinion of many botanists the *Cytineæ* and *Balanophoreæ* do between the fungi and the phanerogams. The resemblance between the two families is so striking, and the forms of both so variable, that one would be excusable for inferring that the podostemes are algæ with phanerogamous flowers; their flowers are, moreover, either apetalous or imperfect, and very simple. They are described by H. A. Weddel as very small plants, which cling to rocks overflowed by running water in the tropical regions of Asia, Africa, and America. The lower forms are composed of little else than parenchyma, while only the larger ones have vascular organs. The stem is either wanting or assumes an extreme diversity of shapes; sometimes it is upright and dichotomous, branched and leafy; sometimes it is like certain mosses; often it is spread on the ground, or attached with a cushion-like foot; sometimes it creeps like a rhizoma or is leaf-like, like the thallus of some liverworts or lichens, and clinging to the stone in the same manner as they do. It has hardly any true roots. Leaves are for the most part absent in the thallus-like species, but are highly diversified in the stemmed species, departing at the same time widely from the ordinary forms; they are seldom square on the stalk, are entire or unequally divided, often forked. The nerves, when they exist, are dichotomous, seldom parallel. The buds, both of the stem and the flowers, are folded convolutely. The cushion-like organs of attachment are elsewhere found only among the algæ; the absence of vascular organs is common to algæ and mosses among green plants, and also to a few phanerogams, as the *Naiadeæ*, *Ceratophylleæ*, and *Lemnaceæ*. As the lower plants of these orders show no differentiation of stem and leaf, at least no more than the algæ, they might be placed, with the *Podostemaceæ* in a group representing a direct transition between the algæ and the phanerogams, for which the provisional name of *Anthophycæ* is suggested. If we also regard the *Cytineæ*, which have no cotyledon, and the *Balanophoreæ*, which have only a simple undivided embryo, as higher forms rising out of the fungi, we may join them as *Anthomycetæ* with the *Anthophycæ* representing the lowest phanerogams, as *Anthothalloidæ*.

Chimborazo and its Climbers.—Referring to the successful attempt of Mr. Whymper to ascend to the summit of Chimborazo, Dr. Nachtigal stated, at a recent meeting of the Berlin Geographical Society, that a Frenchman, Jules Remy, professed to have accomplished the feat in 1856, but it is very doubtful if he did. He gave the height at 7,328 metres (23,816 feet), whereas it is 1,000 metres, or 3,250 feet less. Humboldt observed the height trigonometrically to be 6,530 metres (or 21,222 feet), and Reiss, as the result of three measurements, found the highest of the two peaks to be 6,310 metres (20,507 feet) and the other 6,269 metres (20,374 feet). Humboldt, in 1802, attempted the ascent, but only reached a height of 5,878 metres (19,103 feet), while Boussingault, with Hall, in 1831, reached a height of 6,004 metres (19,513 feet); they attempted the ascent from the south side, while Dr. Stuhel, from the north side, reached a height of 5,810 metres (18,882 feet). After an inspection of ten days, Mr. Whymper made three attempts, and on the third day succeeded in mounting both peaks. The night before the final ascent he spent at a height of 5,227 metres (16,988 feet).

The Comets of 1843 and 1880.—It seems to be well established that the comet which recently appeared in the southern hemisphere is identical with the great comet of March, 1843. This comet, one of the most remarkable in history, appears to have been

first seen by Captain Ray, an American sailor, at Concepcion, South America, at about noon of February 27th, only a short distance in the sky from the sun. On the 28th of February, the head of the comet, with a tail several degrees in length, was observed at noon in various parts of Italy, off the Cape of Good Hope, and at different points in the United States and Mexico. The tail was remarked on the 1st of March in southern latitudes, on the 8th at Lisbon, Portugal, and on the 11th at Montpellier, France, but was not observed in England till the 17th, on the evening of which day it attracted general attention in most parts of Europe.

Hygiene of New-born Children.—The subject of the hygiene of new-born children is engaging the attention of French sanitarians. The present minimum rate of mortality of children under one year old is estimated to be one hundred per thousand. The rate in France is double this, or two hundred per thousand; and the excess is really greater than it seems, for the minimum itself is larger than it should be, and ought, by proper management, to be reduced to eighty and even seventy in a thousand. The chief among the several causes to which the large proportion of deaths is ascribed is artificial alimentation. That the whole physiological development of the new-born child is determined by the character of the food that is given to it, is enforced by all the facts that have been gathered in France. The subject was fully discussed at the International Hygienic Congress, held at Paris during the Exposition of 1878, and some significant facts were presented in illustration of the enormous difference which exists between the mortality of children brought up at home and that of children intrusted to hired nurses and the not less marked difference in the rate of mortality of children nursed at the breast and of children fed artificially. Among children of the easier classes, brought up at home, the rate of mortality often falls as low as 70 or 80 per 1,000; among children intrusted to hired nurses, it was stated to vary from 240 to 750, and even to 900 per 1,000. Among children nursed by their mothers, a rate of mortality was found of only 8·28 per 100; among children brought up by nurses, of 18 per 100 at home, 22 per 100 when they were taken away; among those fed from the bottle, the average was 51 per 100. Dr. Monot stated that, in the department of the Nièvre, in the case of children who had been sent down from Paris without supervision, and had been consigned to hired nurses, the mortality was 710 per 1,000. In the case of assisted children sent out by responsible organizations, under the care of agents and inspectors, it was 240 per 1,000; in the case of those intrusted to nurses who were watched over by the societies for the protection of infants, it fell to 120 and even 90 per 1,000; and, in cases where the young mothers were helped to the means of living, and were able to take care of their children and nurse them, to 70 per 1,000. These facts, though many of them are only approximative, seem to be decisive as to the superiority of maternal nursing. Inasmuch, however, as the number of mothers who can not themselves nurse their babies is very great, and a large proportion of them are not able to hire wet-nurses, the question as to what is the best substitute for mother's milk is an important one. The Municipal Council of Paris has just authorized an experiment which will help answer it. It has decided to establish a nursery in connection with its hospital for assisted children, with stables to be occupied by the various animals usually depended upon for their milk, the milk of which will be given to the children fresh and absolutely pure, in such a systematic manner that the advantages attributed to the milk of each animal may be rigorously and scientifically tested. The whole will be under the direction of Professor Parrot.

Equatorial Temperatures.—Why is the equator not warmer in January, when the earth is nearest to the sun, than in July? Mr. Croll assigns as the reason that the northern hemisphere, which he calls the dominant hemisphere, having its winter in January, the whole earth is colder at that time; also that the northern trade-winds pass farther south in January, and cool the equatorial regions more than at the other seasons. His views are disputed by Mr. A. Woiekoff, of St. Petersburg, who denies

that the winds and condition of the northern hemisphere have any perceptible influence at the equator, and ascribes the mildness and uniformity of the equatorial temperature to the prevalence of the rainy season in our winter, the southern summer months. Water acts during this season to reduce the temperature through its great capacity for heat, through the screen of clouds which it interposes between the sun and the surface of the earth, and through evaporation, and this upon the higher as well as upon the lower strata of air. It is admitted that winds have some effect as aids to the cooling, but the insignificance of their influence, as against any active heat-producing force, and in the absence of moisture, is shown by the fact that the Sahara is the hottest region in the world, notwithstanding the winds that blow over it from the cool Mediterranean.

Messages by Heliograph.—The usefulness of the heliograph was recently satisfactorily tested in the transmission of a dispatch from General Stewart, in Afghanistan, announcing the result of an attack on the British troops, which was sent from Camp Ghuzni, April 22d, and was received at the India Office, London, on the following day. The news could hardly have been brought more speedily by electric telegraph. The heliograph, signaling right over the heads of the enemy, if necessary, to stations which may be few and far between, does not require any route to be kept open, and can not be interrupted. A ten-inch mirror, that being the size of the ordinary field-heliograph, is capable of reflecting the sun's rays in the form of a bright spot to a distance of fifty miles, where the signal can be seen without the aid of a glass. The adjustment of the instrument is very simple. If an army corps, having left its base where a heliograph station is established, desires to communicate with the other division from a distance of several miles, a hill is chosen and a sapper goes upon it with his heliograph-stand containing a mirror swung so as to move horizontally and vertically. A little of the quicksilver having been removed from behind the center of the mirror, a clear spot is made through which the sapper can look from behind his instrument toward the station he desires to signal. Having sighted the station by adjusting the mirror, he next proceeds to set up in front of the heliograph a rod on which is a movable stud, manipulated like the foresight of a rifle. The sapper, standing behind his instrument, directs the adjustment of this stud until the clear spot in the mirror, the stud, and the distant station are in a line. The heliograph is then ready to work, and the sapper has only to take care that his mirror reflects the sunshine on the stud just in front of him to be able to flash signals so that they may be seen at a distance.

Ocean Temperatures in the Pacific and Atlantic.—Herr von Boguslawski has been led, from a comparison of the results of recent deep-sea investigations, to the following conclusions respecting the temperatures of the Atlantic and Pacific Oceans: 1. The water of the North Pacific is, in its whole mass, colder than that of the North Atlantic. 2. The water of the South Pacific is, down to 1,300 metres (4,225 feet), somewhat warmer than that of the South Atlantic, but below this depth colder. 3. The bottom temperatures are generally lower in the Pacific than in the Atlantic at the same depths and in the same degree of latitude; but nowhere in the Pacific are found such low bottom temperatures as in the Antarctic portion of the South Atlantic, between 36° and 38° south and 48° and 33° west longitude, in which bottom temperatures of −0·3° C. to −0·6 C. have been measured. 4. In the western parts of the Pacific, and the adjoining parts of the East Indian Archipelago, the temperature of the water reaches its minimum at depths beween 550 and 2,750 metres (1,787 and 8,937 feet), remaining the same from this depth to the bottom. In the whole of the Atlantic the temperature from 2,750 metres (8,937 feet) to the bottom gradually though very slowly decreases.

The Harvard Medical Course.—Professor James C. White, of the Medical School of Harvard University, states that the enlargement of the course of instruction which was adopted by the department ten years ago has been followed by a general elevation of the standard of medical education through-

out the country, and has been attended by great advantages to the Harvard school. The classes have grown constantly larger, and the quality of the students has improved in nearly the same degree. An admission examination was instituted soon after the new course was adopted, and has recently been made considerably more efficient. The faculty now find that the three years which are allotted to the course are not enough to permit a thorough mastery of all the branches which it embraces, and contemplate adding a fourth year. For the present, the additional year will be optional with the student, who may either crowd all he can into three years as before, or take more time for what has hitherto been attempted in that period, and pursue the special studies which are additionally provided for the fourth year. In the schedule of studies under the new arrangement the main studies of the third year are continued into the fourth year, and an examination will be held at the end of the latter year in a number of special branches, the instruction in which is intended to be more clinical and individual in character than that heretofore given and to take the place partly of the private teaching which American students have heretofore sought in European schools after graduation.

The Cutting Ant.—The Rev. H. C. McCook, of Philadelphia, has made a very interesting study of the cutting or parasol ant (*Atta fervens*, Say), having encamped for the purpose close by its haunts near Austin, Texas. The habitation of the insect was marked by a bed of denuded earth on the prairie, measuring in the case of the one specially examined eight feet nine inches by about seven feet. Over this denuded surface were scattered between twenty and thirty circular, semicircular, and S-shaped elevations of fresh earth-pellets, the circular ones resembling a spittoon three or four inches high, which had apparently been formed by the accumulation of the pellets of sandy soil as they were brought out and dumped upon the circumference of the heap. No life was noticed around the colony during the day, but earthen knobs or warts, and small, irregular heaps of dry leaves, bits of leaves and twigs were noticed scattered over the surface. As evening began, the scene was wholly changed. "Hosts of ants of various sizes, and in countless numbers, were hurrying out of open gates into the neighboring jungle, and two long, double columns were stretched from the bottom to the top of the large overhanging live oak. The ants in the descending columns all carried above their heads portions of green leaves, which waved two and fro and glanced in the lantern-light, giving to the moving column a weird look as it moved along. It seemed like a procession of Liliputian Sabbath-school children bearing aloft their banners. It is this habit which has given this insect in some quarters the popular name of the 'parasol ant.' It is also called in Texas the 'Brazilian ant,' but is quite universally known as the 'cutting ant,' certainly a most appropriate name." The heaps of leaves and twigs lying around the habitation were the closed gates. The opening and closing of these gates occurred before and after every exit from the nest. The process was a long, careful, and complicated one, the opening beginning toward evening, and the closing ending in the morning, sometimes as late as half-past ten. Toward dusk, the minims, or smallest ants, would appear, taking away from the heap particles of sand; larger forms followed carrying away bits of refuse, which they dropped at about two inches from the gate. Finally, the throng would rush out, bearing before them the rubbish, which after a few moments was cleared away from the gallery and spread around the margin of the gate. The litter thus taken away was brought into use again when the gates were closed. In closing the gates, the larger forms did their work first, bringing in twigs, some as long as an inch and a half, and dried leaves, which they deposited to the depth of from a half-inch to an inch and a half below the surface. As the hole was gradually closed, only the smaller forms appeared, and the last touches were carefully and delicately made by the minims, which filled in the remaining interstices with minute grains of sand. A division of labor was noticed in the work of cutting and carrying the leaves. The party consisted of soldier-ants, seeming to act as escort and scouts, the cutters, and the carriers, who took the cut leaves from the base

of the tree and bore them to the nest. This work was not given to the smaller castes. The leaves principally gathered were those of the live-oak. The ants seemed to prefer trees with a smooth leaf, were severe upon grapes, peaches, the China tree, and radishes, took many other garden vegetables and plants, and loved sugar, grain, and tobacco. The interior of the formicary, as carefully examined by Mr. McCook, seemed to consist of an irregular arrangement of caverns of various sizes, communicating with the surface and with each other by tubular galleries. Within the chambers were masses of very light, delicate leaf paper, wrought into a honeycomb-like fabric, hemispherical, columnar, or hanging, composed of cells of various sizes, generally hexagonal in shape, the material of which crumbled under even delicate handling. Large numbers of ants, chiefly of the smaller castes, were found in these cells. Ten distinct castes or sizes of ants were measured, the largest being seven eighths and the smallest one sixteenth of an inch long. Several holes in the vicinity of Austin were visited, out of which nests of ants had been dug. They were nearly as large as a cellar for a small house, one measuring twelve feet in diameter and fifteen feet deep, and the main cavity being as large as a flour-barrel.

The Aborigines of Botel Tobago.—Dr. Charles A. Siegfried, of the United States Navy, in a letter which has been read before the Philadelphia Academy of Sciences, describes a visit he made in December, 1878, to an island called Botel Tobago, about eighty miles east of the south cape of Formosa. He found there a race of aborigines, supposed to be from Malay stock, who knew nothing of money, rum, or tobacco, but who gave goats and pigs for tin pots and brass buttons, and would hang around the ship all day in their canoes, waiting for a chance to dive for something thrown overboard. They wore clouts only, and lived mainly on taro and yams, though they had also pigs, goats, chickens, fish, and cocoanuts. Their thatch houses were low, with overhanging roofs, and surrounded by stone walls strongly made of laid stone to protect them from monsoons. They were peaceful and timid, did not mark the body or deform the face or teeth, and seemed happy enough in their condition, and fairly healthy. They wore their hair naturally, the men partly clipping theirs, and adorned their necks with the beards of goats and small shells. They had axes, spears, and knives, but all of common iron, and their axe was inserted in the handle, instead of the handle being inserted in the axe, as with us. Their canoes were beautiful, made without nails, and usually ornamented with geometrical lines.

Asphalte and Amber in the Mud of New Jersey.—The "Proceedings" of the Academy of Natural Sciences of Philadelphia contain a description of a mass of asphaltum, weighing about a hundred pounds, which was found near Vincenttown, New Jersey, in the ash-mud, a layer above the green-sand proper, about sixteen feet below the surface. It is the first specimen of this peculiar kind of hydrocarbon that is known to have been observed in New Jersey. It is very brittle, black, with a resinous luster, uneven fracture, inclined to conchoidal, melts easily, and burns with a yellow, smoky flame, leaving a voluminous coal and but little ash. It is soluble in chloroform and oil of turpentine, in ether with difficulty; insoluble in alcohol, water, and solution of caustic potassa. Oil of vitriol dissolves it into a black liquor, of which a part is retained in solution in water, a part subsides as a dark-colored powder. Nitric acid reacts upon it at an elevated temperature, forming with it soluble products of oxidation. Near the pit from which the asphaltum was obtained, a specimen was found of a yellow mineral resin, which occurs frequently, but not regularly, in the mud of the cretaceous formation. It is usually called amber, or succinite, but differs from the typical amber of the Baltic in being lighter than water, fusing into a very fluid, mobile liquid, and in having a less strong cohesion, qualities which indicate its analogy to the variety of succinite called krantzite. It burns easily, with a yellowish, strongly smoking flame, leaving but little coal; it may be vaporized into a gray cloud of strongly penetrating odor, which condenses into an oily liquid, and some crystals. It is freely soluble in chloroform, bisulphide of carbon, and oil of turpentine,

sparingly soluble in water, alcohol, and ether, and is partly dissolved by caustic potassa. Cold nitric acid affects it but little. Oil of vitriol makes with it a red solution. The yellowish powder becomes orange-red on warming.

NOTES.

PROFESSOR WILLIAM LEE, M. D., of Washington, is the author of the article entitled "The Extreme Rarity of Premature Burials," published in the August "Monthly." The misspelling of the name was an editorial blunder, for which we beg to apologize both to Dr. Lee and to our readers.

M. TOUSSAINT has been investigating the question of the transmission of tubercle, by means of experiments on the hog. He caused animals to eat the lungs of tuberculous sheep, and tried inoculation by the blood and by milk, and found that the animals became diseased in every case. Similar effects were produced upon healthy animals which lived with tuberculous ones.

THE production of nickel has assumed great importance in Norway within a few years. Eleven mines had been opened between 1861 and 1865, which yielded an average of 3,450 tons a year. In 1875 fourteen mines had been opened, which furnished a maximum of 34,500 tons. The larger part of the yield is exported in the condition of ore, the rest is reduced on the spot.

THE fiftieth annual meeting of the British Association for the Advancement of Science will begin at Swansea, August 25th. Dr. Andrew Crombie Ramsey, Director-General of the Geological Survey of the United Kingdom and of the Museum of Practical Geology, will preside and deliver the opening address. The secretaries are Captain Douglas Galton, F. R. S., and Philip Lutley Sclater, Ph. D., F. R. S., general secretaries, and J. E. H. Gordon, assistant secretary.

THE Swiss Natural History Society will hold its general meeting from the 12th to the 15th of September, at Brieg, in the Canton Vaud.

THE death of Mr. Alfred Swaine Taylor, a well-known English physician and toxicologist, is announced. He was born in 1806, studied in the leading medical schools at home and abroad, was the first holder of the chair of Medical Jurisprudence in Guy's Hospital, and was the author of several professional treatises, especially on the subjects of poisons and poisoning, chemistry, and medical jurisprudence.

THE French Association for the Advancement of Science holds its meeting for this year at Rheims, August 12th to 19th. An exposition of local industry and archæology, and excursions, the most notable of which is to the Han Grottoes, in Belgium, are arranged for in connection with the meeting.

A COMMITTEE was appointed in 1876 by the Academy of Natural Sciences of Philadelphia, at the request of the Centennial Commission, to report upon the subject of the insects and plants that might be introduced to our soil through the medium of foreign exhibits. The report upon plants has been delayed till this year in order that, by taking several seasons for the examination, the committee might be sure that no species escaped them. They now announce that they have found in the Exhibition grounds plants of but thirteen species, and those only in isolated specimens showing no disposition to spread. Some of the species are from the western part of our country, some from Europe, and a few from Japan.

PROFESSOR CHRISTIAN AUGUST FRIEDRICH PETERS, of Kiel, editor of the "Astronomische Nachrichten," died May 8th, after an illness of several months. He was born in Hamburg in 1806; was appointed an assistant in the observatory at Hamburg in 1834; to the Russian observatory at Pulkowa, where he remained for ten years, in 1839; was named Professor of Astronomy in the University of Königsberg in 1849; and director of the observatory at Altona, which was afterward removed to Kiel, in 1854. His most important memoirs were on "Nutation," on "The Parallax of the Fixed Stars," and on the "Proper Motion of Sirius."

PROFESSOR W. H. MILLER, of the University of Cambridge, died May 20th, in his eightieth year. He succeeded Dr. Whewell as Professor of Mineralogy in 1832, and published his treatise on "Crystallography," a work which was almost universally accepted as a standard, in 1838. His "Manual of Mineralogy" appeared in 1854, and was full of the results of his own research. He was the author of several other books and memoirs.

AT a show of birds lately held in Berlin, several canaries were exhibited that attracted much attention on account of the peculiar colors of their plumage. Some were green, others red and light brown, and others of a soft gray tint, while all differed more or less from the light yellow of the common bird. These variations of color were produced by the daily use of cayenne pepper in the food of the birds. The pepper is given in small quantities at first, and the birds appear to like it, but the immedi-

ate effects are anything but pleasing to the beholder. The feathers soon begin to fall, giving the bird very much the appearance of molting; in a short time, however, new feathers make their appearance, and it is then, as they attain full growth, that they exhibit the curious tints observed.

PROFESSOR C. W. CLAYPOLE, of Antioch College, Ohio, has recently been examining the Schliemann collection of antiquities in the South Kensington Museum in London, and he concludes that the names attached to some of the objects in the collection betray a rather unwarrantable use of the imagination. Among others, the little hour-glass-shaped pebbles labeled "Minerva Ornaments," and hitherto regarded as idols, are in his opinion nothing more than "Trojan net-sinkers," being almost identical in form and appearance with the "net-sinkers" frequently found on the shores of our lakes and rivers.

DR. JAMES PRESCOTT JOULE has received the Albert Medal from the Society of Arts, for having, as the award reads, established, after most laborious research, the true relation between heat, electricity, and mechanical work.

DR. PAUL BROCA, the distinguished French anthropologist, was taken ill at the session of the French Senate of July 8th, and died the following night. He was fifty-six years old, and had lately been elected a life-member of the Senate.

HOLLAND has lost its leading chemist by the death of Professor G. J. Mulder, of Utrecht, which took place in May last. Professor Mulder was born in 1802, and, previous to taking the chair of Chemistry at Utrecht in 1841, served as Professor of Botany and Chemistry at the Rotterdam Medical School. He made a variety of researches and discoveries in the chemistry of vegetable physiology, and in animal chemistry proved the presence of carbonic acid as a normal constituent of the blood. He was the author of numerous works, and the editor from 1842 to the time of his death of the only chemical journal of Holland.

M. CAMILLE FLAMMARION has been awarded the Monthyon prize of the Paris Academy of Sciences for his new work on "Popular Astronomy" ("Astronomie Populaire").

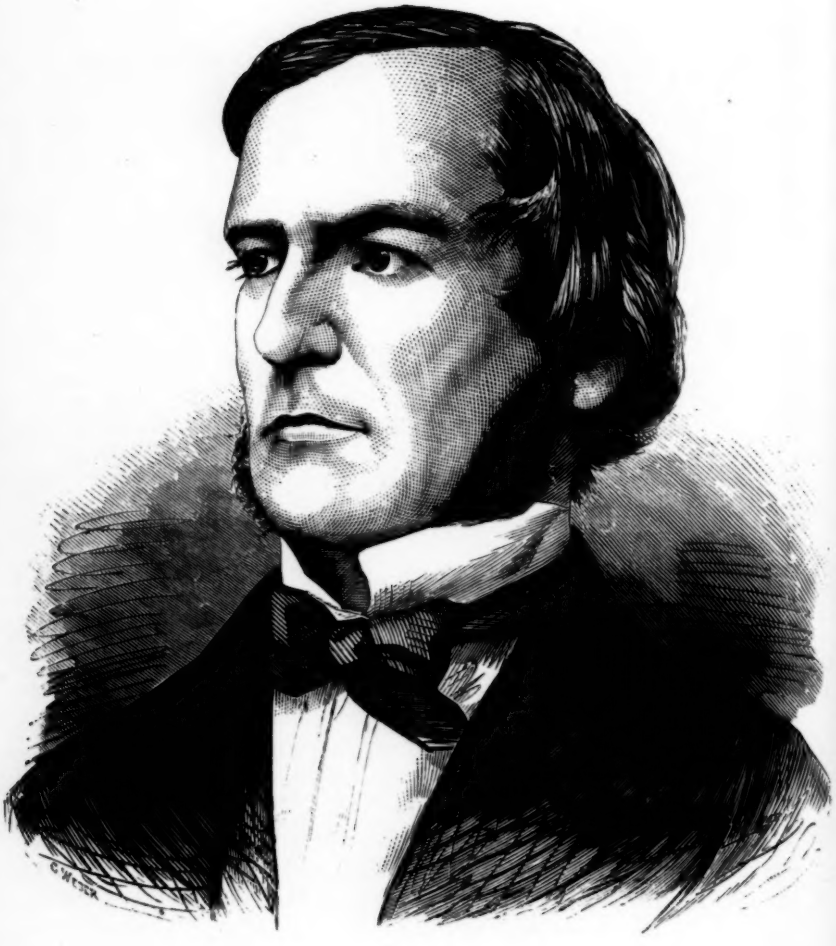
LETTERS recently received in England from Mr. Whymper state that he has found very extensive glaciers on the mountains Cayambe, Sarauscu, and Cotocachi, and had previously discovered other glaciers on Chimborazo, Sincholagua, Antisana, Cotopaxi, Iliniza, Carihuairazo, and Quilindaña. Many of these glaciers are as large as the largest Alpine ones, and the upper four thousand feet of Cayambe, Antisana, and Chimborazo are almost completely enveloped by them. Mr. Whymper is contributing largely to our knowledge of these mountains, for the last edition of the "Encyclopædia Britannica" mentions the glacier of the mountain Altar as the only real glacier known to exist in the Ecuadorian Andes.

THE entire absence of scurvy during the voyage of the Vega is attributed by Professor Nordenskjöld to the free use of a little berry that springs out of the ice and snow during the summer. It bears profusely, and has a taste like the raspberry, but more acid. The fruit is dried and mixed with the milk of the reindeer, and can be carried in a frozen state for thousands of miles. It appears also that the party were never wholly without daylight, having two hours of it during the shortest day, although the sun was not above the horizon.

THE Custos of the Berlin Agricultural Museum, Dr. L. Wittmacht, has lately been engaged in the examination of some partly carbonized seeds which were found by Virchow and Schliemann in their excavations. Among them were a vetch (*Ervum Ervilia*, L.), field-beans, and peas. The discovery of the peas is the more interesting because, according to several authors, peas were unknown to the ancient Greeks. A remarkable seed was a hard wheat, extremely small grained, very sharp, closely pressed, extraordinarily flat on the furrowed side. The grains are wholly different from those of every wheat hitherto known, and are especially distinct from the thick-bellied grains of the Egyptian mummy-pits and of the lake-villages.

A PRACTICAL test of the efficiency of the electric light in naval operations was made recently on board two vessels of the British navy at Gibraltar. During the practice, which was continued for nearly an hour, every hole and cranny on the western face of the rock was searched out and illuminated with the clearest distinctness, and every boat and vessel in the bay underwent a similar minute examination. Only a limited surface could, however, be illuminated at a time, so that the process of search was somewhat slow.

M. BOITEAU has reported to the French Academy of Sciences that the application of sulphide of carbon as a cure for the phylloxera has proved thoroughly successful. Diseased vines, which were treated with this substance two or three years ago, look even better now than they did before they were attacked; and it seems established that the sulphide has no damaging effect on the productiveness of the soil. The only drawback to the use of the substance is its scarcity and consequent high price.



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